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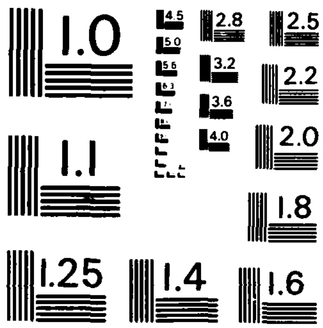

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A SLAM MODEL OF THE ARMED FORCES COURIER SERVICE CONUS STATIONS:
A STRATEGIC PLANNING TOOL

THESIS

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A SLAM MODEL OF THE ARMED FORCES COURIER SERVICE CONUS STATIONS: A STRATEGIC PLANNING TOOL

THESIS

Presented to the Faculty of the School of Systems and

Logistics of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Logistics Management

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Preface

The purpose of this study is to provide the Armed Forces Courier Service a strategic planning tool to assist in the analysis of their complex route structures.

We wish to convey our appreciation to those individuals who contributed their time and assistance to the preparation of this thesis. We especially thank our advisor Major William Rowell and our reader Lt Col Palmer Smith for constructive advice and expertise. Their guidance contributed significantly to the successful completion of this project.

We also wish to express our appreciation to the people of the Armed Forces Courier Service, particularly the Director, Captain Jackson, USN, and the USAF commanders, Lt Col Larry Fisher and Major Frank Morrissey; they provided the initial impetus for the study. Without their cooperation and technical expertise this study would not have been possible.

Finally, our sincerest thanks and appreciation to our wives for their support and patience. Thanks to Erica for her artwork on the maps, and thanks to Lin for living without a husband this past 15 months.

Winston D. Nelms   Douglas E. Steward

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ABSTRACT

This research develops an analytical model to assist the management of the Armed Forces Courier Service (ARFCOS) in making strategic planning decisions concerning its complex transportation network. ARFCOS delivers highly sensitive classified information to approximately 6500 customers served by 36 stations around the world. The research is limited to modeling 14 CONUS ARFCOS stations (ARFCOSTAS). The model is used to evaluate the current transportation network structure, determining the required weight bearing capacity of the vehicle to meet the maximum loading anywhere along a route. The model also provides data on manpower usage in terms of average number of people working and minimum and maximum number of people needed at one time. It provides the managers of ARFCOS a tool for analyzing alternative systems and the means of comparing different decision rules on the working of the system.

Simulation Language for Alternative Modeling (SLAM II) is the implementing language of the model. The theoretical distribution of the amounts of material picked up and delivered to 361 demand points are determined and used to compute maximum expected weights along 71 routes. The model is validated as an accurate representation of the current ARFCOS system. Conclusions and recommendations for consolidating stations, reallocating customers, and

changing modes of transportation are discussed. The effects on manpower requirements of implementing selected alternative route or station locations are analyzed using the provided model.

A SLAM MODEL OF THE ARMED FORCES COURIER SERVICE
CONUS STATIONS: A STRATEGIC PLANNING TOOL

I. INTRODUCTION

General Issue

The mission of the Armed Forces Courier Service (ARFCOS) is "the secure and expeditious movement of the nation's highly classified information among elements of the Department of Defense, other U.S. Government elements, civilian contractors requiring classified materials and certain foreign or treaty organizations" (9). ARFCOS requires a strategic management tool for analyzing the economy and efficiency of their transportation networks. Due to the complexity of delivery routes and volume and frequency of delivery requirements, manual computation of schedules and routes as well as distribution site selections have become significant management problems for ARFCOS. There is a requirement to have easy-to-use, computerized models to assist in the design of delivery routes for both air and surface transportation modes and to aid in selecting station locations (distribution sites). This thesis explains the development of a simulation model that provides the ARFCOS top managers with a strategic planning tool for determining vehicle weight carrying requirements, and manpower needs for their different routes. The ability to calculate this information will allow ARFCOS management to make more informed decisions concerning modes of delivery and manpower allocation.

History and Organization of ARFCOS

The Armed Forces Courier Service was established January 1953 as a tri-service agency of the Joint Chiefs of Staff (JCS). It is comprised of the headquarters, located at Ft. Meade, Maryland, and 36 Armed Forces Courier Stations (ARFCOSTAS) located around the world. The stations are staffed by Army, Navy or Air Force personnel depending on the location and primary customers. The three services have combined to issue Army Regulation 66-6/OPNAV Instruction 5130.1A/Air Force Regulation 183-1, which constitute the ARFCOS charter. Although AFRCOS is an agency of the JCS, the Chief of Staff of the Army serves as executive agent for ARFCOS. He, in turn, has delegated the responsibility to the Army Adjutant General. The Director, ARFCOS, reports to the Adjutant General and operates the service (3).

Although ARFCOS is a tri-service organization, the Army, Navy, and Air Force each have estabished an organization to carry out the command and support of their respective courier organizations and stations. However, the actual courier service operations are controlled by the Director, ARFCOS, who is concerned with the safeguarding and transporting of, and accounting for classified material (3). To ensure close coordination among the service elements, the three service courier commanders work at ARFCOS headquarters and are directly involved in the day-to-day ARFCOS activities.

ARFCOS delivers highly sensitive, classified information to approximatly 6,500 customers served by 36 ARFCOSTAS around the world (9). The largest category of material in both pieces and weight is cryptographic and cryptologic material. These pieces range in size from a key list contained in a letter size envelope to a large piece of scrambler equipment used for world-wide White House communication.

Security is the primary concern in the transportation of ARFCOS material. The unknown compromise of classified material could cause irreparable damage to the interests of the U.S. Government and could also result in the nullification of a considerable amount of intelligence effort. The U.S. Intelligence Board estimates that the material carried by ARFCOS yearly constitutes the result of approximately ten billion dollars in expenditures (9).

The key to the security of the material entrusted to ARFCOS is accountability. A responsible person is at all times accountable for the material. His/her primary function is to know if any unauthorized person has had access to the material, not necessarily to stop that access. The

ARFCOS couriers are not armed and are not trained to prevent road or air hijackings. They travel in their normal service uniforms in military and commercial vehicles. The security comes from knowing what has been compromised, and then taking steps to nullify the effects of that compromise.

ARFCOS uses several modes of transportation to move this classified material. ARFCOS relies primarily on military and commercial airlift to move bulk volumes of material from one station to another. ARFCOSTAS use a combination of air taxi contract flights, military flights, and military ground vehicles to serve their customers. The complexity of the transportation problem is most evident at the station level where as many as 500 accounts must be served.

Each station manager has the responsibility for managing his own operation, as well as coordinating movement of materials to other stations. Each station develops routes and delivery schedules. Day-to-day activities, including documentation, security, and delivery of materials, are managed by station personnel with general guidance in the form of regulations provided by HQ ARFCOS. Guidance from headquarters dictates at least one courier must accompany the material in the vehicle, regardless of mode of delivery. Most often, the station managers have two couriers escort the material on a trip, due to the need for leaving the vehicle to deliver material to a specific stop. Generally, a route is set up to serve an account on a specific day on a recurring basis.

Routing between stations is determined at ARFCOS Headquarters. A station's manpower and budget requirements are a function of its activity level -- number of customers, volume of cargo handled, and travel time required to serve customers. Number of personnel assigned and funds allocated are determined at headquarters level, normally based on historical data, inputs from the stations, experience, and judgement.

CONUS ARFCOSTAS are located at Boston, MA, McGuire AFB, NJ, Dover AFB, DE, Ft. Meade MD, Norfolk, VA, Charleston AFB, SC, Jacksonville NAS FL, Wright-Patterson AFB, OH, Offutt AFB, NE, Kelly AFB, TX, Denver CO, McChord AFB, WA, Travis AFB, CA, Los Angeles AFS, CA, and San Diego, CA. The main station is at Ft. Meade, MD. It operates as the major connector between most of the ARFCOSTAS, both CONUS, and overseas. It also serves the Washington, DC area, which encompasses the largest number of users of the ARFCOS service. It is a 24-hour-a-day operation, with over 100 couriers, assistant couriers, and drivers assigned. The other stations are all much smaller, having between eight and 18 people assigned. San Diego, Kelly, and Norfolk have production facilities which generate tremendous weights of material to be moved. Los Angeles generates very little compared to them, and Dover produces hardly anything (12).

The locations of the stations have not been part of any master plan, and the decision rules on opening, closing, or moving stations have not been explicitly formulated. When new customers are added in the system, ARFCOS has no way of determining which station would provide service at the least possible increase in operating costs, measured by extra time on the road. The geographical areas of responsibility for each station are not clearly defined. For example, Dover serves some parts of New York, while McGuire serves others.

Research Objective

The general objective of this research is to develop an analytical model to assist the management of the Armed Forces Courier Service in making strategic decisions concerning its complex transportation network. The model is used to evaluate the current route structure of the CONUS ARFCOSTA, determining the weight capacity of the vehicle required for each route. The model also provides data on manpower usage in terms of average number of people working, as well as the maximum and minimum number of people needed at any one time.

Specific Problem

Using the model to analyze existing ARFCOS CONUS transportation networks, the following questions are addressed:

1. What weight bearing capacity must the vehicle have for each of the various routes?

2. Can any stations be consolidated and still meet

customer needs and security requirements?

Research Questions

1. Where are the sources and final destinations of the cargo?

a. How much weight is picked up at each point?

b. How frequently is each customer served?

2. How much manpower is required to provide the current level of service?

a. How many separate trips are required to satisfy all demand?

b. What service method (air or ground) is employed?

II. RESEARCH METHODOLOGY

Introduction

This thesis approaches the Armed Forces Courier Service (ARFCOS) system of Armed Forces Courier stations (ARFCOSTAS) as a distribution network. The 15 CONUS ARFCOSTAs serve 289 distinct demand points--locations which must either be delivered to or picked up from. Most of these points are consolidated pick up and delivery points where several customers are all served at the same location. Each demand point must be served periodically, the exact frequency of which has been determined by the management of ARFCOS. Factors which contribute to the required frequency are the time sensitivity of the items to be moved, the regularity of material generation, and if the customer feels he needs more frequent service than the other considerations would normally allow, his willingness to incur the costs of extra service trips (12).

This thesis models the current ARFCOSTA network. The network is operating at a known customer service level with a known number of man-years required to maintain that level. A man-year is defined as the number of hours one person works in one physical year, approximately 2000 hours. The major question the ARFCOS staff would like to be able to answer is how alternative ARFCOSTA locations would change the amount of manpower required, and how much would it cost to operate the system in that configuration. The objective is to find alternatives that are less expensive to operate than the current one while at least maintaining customer service levels. This is a facility location problem: given a set of sources of materials and demands for them, where should the distribution centers be located so as to minimize costs while satisfying demand?

This thesis does not delve into detailed cost analysis. Costs may be very difficult to estimate when dealing with military organizations. The cost comparison between distribution centers located on military reservations, where few costs are directly borne by the user, to identical facilities outside the reservation with fixed rental costs and operating expenses, is difficult to make at best. When deciding where to locate stations, the cost differential must be weighed against the possible extra time or manpower needed to meet the mission. Assuming that the total manpower of the services is currently effectively used, the manpower costs would include the total costs over the career of the courier including initial procurement, training, salary and retirement costs.

Problems other than the computation of costs complicate this facility location problem. Specifically, how does one assign the demand points to the distribution sites? After all of the demand points are assigned, they must be served periodically. What routes will be used to serve those customers? One way of assigning responsibility is proximity to the demand point. Roads are not always straight lines between two points, so the determination of distances can be difficult. Also, other transportation networks interact with the ARFCOS network. LOGAIR, the Air Force Logistics Command (AFLC) air service used for moving parts and other materials among Air Logistics Centers, QUICKTRANS, the Navy equivalent to LOGAIR, and commercial aircraft routes are available; their routes may allow one distribution point to be the most economical server of a station outside of normal distance parameters. For example, because of the LOGAIR routes, Wright-Patterson AFB ARFCOSTA serves Loring AFB, Maine, even though the ARFCOSTAS at Boston, McGuire AFB, and Dover AFB are all closer.

Another problem considered is determining the most likely vehicle size needed for any given route. Each of the consolidated pickup and delivery points has a variable amount of material to process each time it is served. The demand of some points are much more variable than others; some of the points account for most of the pieces or weight of the route. Knowledge of the maximum expected weight of the route is important in order to use the least cost vehicle for a route. This becomes especially important in leasing small aircraft, where the difference of 500 pounds lift capability can cause the costs to triple (12). It is also important in determining whether it is less expensive to fly or drive a route, because the extra costs of the aircraft may be made up in the lack of per diem payments and the extra availability of the people.

Potential Solution Approaches

"Management Science is a broad discipline which includes all rational approaches to managerial decision making that are based upon an application of scientific methodology" (2:2). Included are the disciplines of operations research, decision sciences, and systems analysis. For the purposes of this study, all are subsumed under the heading management science.

Management science offers many potential tools for helping determine where ARFCOSTAS should be located, the manner in which the customers are serviced, and which ARFCOSTA is responsible for providing that service. Among the available techniques are a variety of optimization techniques (linear programming, goal programming, dynamic programming), systems simulation, heuristic programming, and combinations of the same. Each technique is useful, and the choice of technique(s) is dependent on the characteristics of the problem and the questions being addressed (1:122). No one technique is robust enough to capture the entire system so a combination of techniques must be used.

Optimization Techniques. Linear programming (LP) techniques minimize or maximize a measure of system performance subject to a set of restrictions. They have many applications, including optimum selection of the optimum locations of facilities and allocation of resources (1:165). In broad terms, LP is an aid to decision making (2:24).

To answer the question "How many courier stations should we have?" a comprehensive distribution planning model with optimization capability is needed (8). A. M. Geoffrion and G. W. Graves used a mixed integer linear program to solve a problem involving 14 supply points, 45 possible distribution center sites, and 121 customer zones. They developed a solution technique based on the decomposition of the problem into a number of smaller, similar problems, and found an essentially optimal solution (7:822). Their formulation of the problem is inappropriate for this thesis because they assume a single time period, and they require a fixed warehouse capacity.

The ARFCOS problem requires a dynamic approach. That is, the flow of the system through time is important, and the warehouses, while constrained by capacity limits (capacitated) in reality, are better modeled as unconstrained (uncapacitated). This uncapacitated formulation allows the throughput to be measured and the maximum capacity required to be generated by the simulation run. The capacity constraints can then be used in strategic planning and budgeting to see where construction funds should be spent.

An alternative LP formulation of the problem by Tony J. Van Roy and Donald Erlenkotter (21:1091-1105) models the dynamic uncapacitated facility location problem. The size of the ARFCOS network, however, makes their formulation unwieldy. The primary reason for not selecting optimization techniques is the lack of information needed to adequately model the distribution center. The problems of lack of cost data in operating the stations at non-military locations, lack of ways of measuring the opportunity costs involved in operating on military installations, and the extreme variability of demand at the various consolidated points, make optimization extremely difficult to accomplish.

Heuristic Techniques. Heuristics are aids to discovery, rules of thumb employed to simplify problem solving. Among the heuristic techniques available are "generate and test" (also known as exhaustive enumeration), a weak method of problem solving, which requires a generation of possible solutions and a test to ascertain if the possible solution is indeed a real solution. One can open a combination lock with this method. It is evident that most problems are too complex to be solved in this manner, but the technique is so general as to be useful with other techniques. Two other methods are hill climbing and heuristic search. In hill climbing, the previous "best" solution is compared to the currently generated solution to determine which to keep. There is no guarantee of obtaining an optimum with this, or any other heuristic technique. Heuristic search looks upon a problem as a "search through an exponentially expanding space of possibilities -- as a search which must be controlled and focused by the application of heuristics" (13:386).

Some have argued that heuristic programming is not a valid approach to be used by reputable practitioners of management science due to its lack of rigorous proof, that is, its not being defined by a specific algorithm. Because heuristics are being used as a tool to make the problem tractable, and because the nature of the problem is such that exact analytical methods, like linear programming are unusable, it is not unreasonable to use heuristics (16).

Marshall Fisher reviewed several heuristic algorithms for different problems to determine their worst-case performance. None of the heuristics reviewed had bad average performance, but one worst-case performance of a traveling-salesman problem was atrocious. He concluded that much work needs to be done in the theory of worst-case analysis of heuristics (6).

Systems Simulation. Systems simulation is "the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies for the operation of the system" (20:2). A model is a representation of an object, system, or idea in some form other than that of the entity itself (18:4). It is built for the purpose of studying the system (4:9). A system is defined as " An isomorphic representation of the real phenomenon expressed in a different, more organized fashion" (18:304). It includes both objects and relationships among the objects. A system is an entity or whole and may be broken down into subsystems, each of which may be considered as a system in its own right. An output of one system is an input into another system (18:12-13). More is said about systems simulation in the next section.

Chosen Solution Approach

System simulation was chosen as the most appropriate approach. The model built to represent the ARFCOS distribution network is a computer simulation model. As such, it provides a range of outputs reflecting the variability in the inputs, and the faithful representation of the system. Shannon suggests the appropriateness of simulation under circumstances where comprehensive mathematical formulations of the problem either are nonexistent or mathematically intractable; conducting experiments on the system is desired, but not permitted; or time compression is required (20:11). A simulation model generates an artificial history of the system based upon the model assumptions; this history is analyzed, and used to predict the manner in which the real system would behave under analogous circumstances (4:11). Since one cannot open and operate an arbitrary number of ARFCOSTAS at alternate locations to determine the effect on the operation of the system, a simulation provides the perfect tool for determining the answers to these "what if..." questions.

In keeping with Shannon's ideas concerning the characteristics of a good simulation model, the simulation models used in this thesis are designed to be:

1. Simple for the intended user to use and understand.

2. Complete on important issues.

3. Easily updated.

4. Easily expanded. (20:26)

An objective of this effort is to produce a model which can be used, modified, and understood by an inexperienced programmer: one which meets Schruben's desired characteristic of credibility -- reflected in the willingness of the users to base decisions on the information from the model (19:101). Models fulfill so many functions, it is almost impossible to classify them all (20:5). Authorities agree modeling supports decision making by aiding in problem identification, and supporting the alternative selection process (20:5-6; 19:139). This model is built to provide the managers of ARFCOS with the means of analyzing alternative systems on paper and the means of comparing the impact of different decision rules on the working of the system.

Language Selection

Simulation Language for Alternative Modeling (SLAM II) is the implementing language of the model. SLAM II, however, has many possible ways of modeling a system. SLAM II was chosen for a number of reasons, not the least of which was the availability of a microcomputer version of the language which would run on ARFCOS equipment. SLAM II is an easy to use and learn language, is very self documenting when written properly, and has good error diagnosis capabilities; these characteristics facilitate model building, and model modification. SLAM II supports more than one modeling perspective. Because others may use the ARFCOS models developed to do further research, a discussion of alternative modeling orientations available in SLAM II is presented.

World Views. A world view is "a conceptual framework for describing the system to be modeled . . .the world view employed by the modeler provides a conceptual mechanism for articulating the system description" (17:60). The model of a system may be either discrete change, or continuous change. In discrete change models the condition of the system only changes when an event occurs; in a model of a bank, a customer walking into a bank is an event which changes the state of the system. In continuous change models, the condition of the system is changing continually over time; in a model of a river, the position of a boat is continually changing. These terms apply to the model, not the system, for it may be possible to model the same system with either model. SLAM II provides a highly flexible framework for modeling. It can model networks; discrete change systems; combined network, discrete event systems; continuous change models; and combined network, discrete event, continuous models.

The models of the courier stations are network models. The network modeling approach consists of defining the system as a set of entities which flow through a series, or network, of nodes, and activities. An entity can represent a person, a vehicle, or whatever the modeler wants it to be. Entities may be assigned attributes, which are characteristics of the entity. For example, in modeling a bank, one could use entities to represent customers, and assign attributes to represent waiting time in the line, and amount to be deposited or withdrawn. This allows the individualization of entities. These attributes are attached to the entity as it flows through the system. The entities compete for the system resources. Entities use resources, such as tellers, vehicles, or couriers, to accomplish their functions. SLAM automatically maintains statistics on resource use.

The network perspective is easy to implement into SLAM II code, and easy to modify in order to test alternatives. If it is possible to model a system as a network, then this is the preferred approach. The models which can not be accurately represented by the available network elements must use one of the alternate modeling approaches such as those discussed in the following paragraphs.

In discrete event modeling, the system is modeled by "describing the changes that occur in the system at discrete points in time. . .and is constucted by defining the events where changes in system states can occur and then modeling the logic associated with each event type" (17:229). In a bank model, for example, the system changes when either a teller becomes available for another customer or when a customer enters the building. The changes that occur upon a customer arrival concern either being waited upon, or waiting. The changes that occur when a teller becomes available concern either serving another customer, with a change in the length of the waiting line, or being available for the next customer who walks in, going on lunch break, etc. Discrete event modeling requires interacting with FORTRAN subroutines, and is not as easy as network modeling. The increased modeling flexibility is obtained by an increase in modeling effort (17:323).

Combined network, discrete event models add the flexibility of the FORTRAN subroutines to the ease of the network statements. The advantages of both world views are combined into a single modeling framew which permits a model to be represented using a combined approach (17:323). This over-comes the disadvantages of the strictly network model, but the programming effort is still increased.

Continuous modeling characterizes the system by a set of equations; a model consists of sets of algebraic, difference, and differential equations, containing either deterministic or stochastic components which are time dependent (17:370). The model interactions must be expressed in mathematical terms, and the flow of the process must be capable of being expressed mathematically.

Finally, the combined network, discrete event, continuous model is the most all-encompassing, and most difficult to program and understand. It can also model the most complex processes.

This model employs the network approach because of the relative ease of programming; the ability for an inexperienced person to look at, understand the process, and modify it; and the ease of executing the model on the computer. Entities are both routes and work periods, depending on what occurs in that portion of the network.

Data Collection

In order to adequately model the routes, information on the supply and demand at each location had to be collected. Prior to this thesis, no model of the ARFCOS CONUS distribution network existed. Although the data were available, no analysis on the distribution of supply, the amount of material put into the system by each customer, or demand, the amount each customer received, had been made. That is, though the managers knew which locations were the biggest users of their services, they did not know the distributions of those demands.

ARFCOS, by the nature of its business, maintains records of every piece which flows within their network. The record shows the source of the material, its weight, and it's sink (destination). Since this study models only the CONUS operation, all materials originating overseas have been aggregated into the port of entry's source data, as have all pieces destined for overseas locations been added into the demand for the port of debarkation. The amount of supply or demand for a particular location is the weight of materials originating from or destined for that location. All of the data needed for determining supply from the customers were obtained from monthly activity reports from the ARFCOSTAS. The data used are taken from the April 1984 through March 1985 Cost and Channel Reports (figure 1) for each of the fourteen ARFCOSTAS. Data used are the weights indicated in columns (i) and (k) of the reports. Column (i) lists the weight of the materials picked up at the designated location, and column (k), the weight delivered to the destination. The weights indicated in those columns are aggregate monthly data, regardless of how often the point was served. Columns (j) and (l) are used to report material flowing between the ARFCOSTAS.

CHANNEL AND COST REPORT (RCS ARFCOS [illegible]) Sep 84

FROM

TO

CHANNEL (a)	COURIER (b)	(c)	(d)	(e)	(f)	(g)	(h)	MATERIAL WEIGHT/PIECES (i)	(j)	(k)	(l)	(m)	COST (n)
MOFFETT	7			CHC				4252-240		4997-306			
LIVERMORE	4			"				85-22		206-29			
STOCKTON	2			"				82-3		90-10			
MATHER	3			"				97-7		311-42			
BEALE	3			"				89-8		524-57			
MERCED	2			"				1-1		437-11			
FRESNO	2			"				2-2		285-19			
LEMOORE	2			"						315-13			
MONTEREY	3			"				86-29		598-97			
LOCAL DELIVERIES								2135-28		3679-97			
SPECIAL TO SN (NOTE 2)							$51.50						
PERDIEM COST FOR LOCAL TRIPS (See Note 4)							$239.00						
STAFF VISIT BY CC TO AN (See Note 3)						$215	$142.0[illegible]						
TOTAL	58	13	19		---	$2645	$1837.31	7104-426	25[illegible]474--187	12956--886	249427--144	$11,920	

TYPE NAME, GRADE & SERVICE: DAVID N. MOSSOW, CAPT, USAF Commander

AUTHORIZED SIGNATURE: [signature]

REMARKS:
1. PERDIUM CA, AIR FARE/GBL COST FOR 8 STREAMER TRIPS/8 COURIERS.
2. PERDIUM COST FOR SPECIAL TO SN BY [illegible] STAVENAU.
3. PERDIUM COST/CA AIR FARE FOR STAFF VISIT BY CC TO ARFCOSTA AN.
4. PERDIUM COST FOR LOCAL FLYING TRIPS ON CON[illegible] AIRCRAFT

Fig 1. ARFCOS FORM 13

Data Analysis

The ARFCOS records were statistically analyzed for total supply/demand as well as the underlying distribution. These distributions are used in the simulation to estimate the performance of the existing systems. Weights were collated by distribution point and by direction (into or out of a location) for twelve months. This provided two sets of twelve data points for each location served by each of the ARFCOSTAS totaling approximately 800 data sets. Each set of data was then analyzed for its underlying distribution using the AID Computerized Theoretical Analysis Package developed by Pritsker and Associates, Inc.

AID offers two goodness-of-fit tests for performing the analysis of data. Either the Kolmogorov-Smirnov one sample test (K-S test) or the Chi-Square test can be used depending upon the data being analyzed. The KS test is appropriate for this study because the number of observations in the samples being analyzed was insufficient to meet the number of observations per cell that is required by the Chi-Square test.

The K-S test requires that the cumulative frequency distribution that would occur under the theoretical distribution be specified. This distribution is then compared to the observed cumulative frequency distribution derived from the sample data. The point at which the greatest difference between the theoretical and observed distributions exists is determined. This maximum difference is compared to the appropriate critical value from the K-S one sample test table, which is determined by the number of sample values and desired level of confidence.

AID allows testing against ten continuous distributions, and two discrete distributions. The continuous distributions available are uniform, triangular, normal, lognormal, exponential, erlang, gamma, weibull, beta, and beta-PERT. The discrete distributions available are uniform, and poisson. AID provides relative frequency and cumulative frequency histograms comparing the sample data with the theoretical distribution chosen, allowing the user to see how well the theoretical probability function fits the observed data. The K-S test statistic, parameters of the distribution, mean, standard deviation, and the critical value of the K-S statistic for the number of observations and desired level of confidence are provided as output of the analysis package.

Because of the small number of observations available, many sets of data passed the K-S test for more than one distribution. Each set of data was compared to all of the distributions which seemed reasonable. (A look at the histogram eliminates some distributions as obviously wrong. Also, the normal was eliminated because of the possibility of generating negative numbers with that distribution.) The distribution chosen to model the demand at the location was based on the minimum value of the K-S statistic.

Because only data on total monthly supply and demand were available, it is assumed that the monthly demand can be divided by the number of visits to a point without adversely affecting the results. The expected monthly demands would be the same regardless, but the distribution of the aggregated month might be different than the sample data. This opens the possibility of underestimating the maximum weight in the vehicle, and the variability of the maximums. In cases where one month of the year the material weight was so much larger than the other eleven that no distribution could be found to model the location, the model allows for the entire large amount to be picked up or delivered at one time. This opens the possibility of overestimating the weights in the vehicle, and the variability of the maximums. Because theoretical distributions are used, which generate a broader spectrum of values than the sample data, the researchers feel the simulated maximums are on the right order of magnitude. With the increase in the use of computers in the ARFCOS system, the data may, in the future, be reported for individual trips, rather than the aggregated data. Currently, however, this information is not readily accessible. The primary thrust of this thesis is to build a model for them to use. It is very easy to correct any deficiencies in the distribution data by changing the values in the model. The data analysis techniques used are valid for less aggregated data.

When ARFCOS originally presented this topic for study they thought they had a data base containing true source-destination data; that is, weights and pieces data from every point in the system to every other point in the system. This is the kind of data needed to approach the problem as a facility location problem. However, that data base fell apart due to inconsistant data entry, and the data base was useless.

Summary

Research Question #1. The methodology used to answer research question #1, determining the sources and final destinations of the material within the system consisted of compiling the records of ARFCOS to determine totals, and applying histograms and goodness of fit tests to the data to estimate distributions.

Research Question #2. The simulation model provides the evaluation of all the routes of the CONUS ARFCOS system (except the Ft. Meade routes) determining the maximum expected weight carrying capacity of the vehicle. Twenty six months of data are simulated, and a confidence interval on the maximum weight bearing capacity required is computed. Monthly utilization rates of the couriers are computed by SLAM II.

III. THE SIMULATION PROCESS

Introduction

In *Systems Simulation, the Art and Science*, Shannon describes the process of simulation in eleven stages, from system definition to documentation (20:23). This chapter introduces, defines, and expands on this eleven stage process which serves as the developmental guide to this model.

The Process

The eleven stages in the process are:

1. System definition
2. Model formulation
3. Data preparation
4. Model translation
5. Validation
6. Strategic planning
7. Tactical planning
8. Experimentation
9. Interpretation
10. Implementation
11. Documentation (20:23).

System Definition

"The first step in defining the system to be studied is to make an analysis of the need environment" (20:26). ARFCOS needs a model to manipulate in order to determine weight capacity requirements along both their existing and possible routes. The simulation is a detailed network depiction of all the routes, and daily operations of fourteen CONUS ARFCOSTAS. The Ft. Meade station is not modeled. Each served location, regardless of how miniscule or great the amount of material supplied or demanded, is modeled. This level of detail is justified on the basis of the future questions which the ARFCOS managers may ask. This allows easier analysis of alternate route structures. The modeling of the daily operations within each ARFCOSTA allows management to calculate the effect of establishing ARFCOS-wide manning policies on the total number of hours worked by the station personnel, and the maximum manpower demands during the daily operations.

The system is separated into six models. The degrees of interaction between the various ARFCOSTAS, the amount of overlap of their areas of responsibility, and the size limitations of the microcomputer version of SLAM II determined which stations are modeled together. Modeled together are: Dover, Boston, and McGuire; Jacksonville, Charleston, and Norfolk; Offutt, Denver, and Kelly; Travis and McChord, and Los Angeles and San Diego. Each set of stations contains geographically close ARFCOSTAS with overlap in their routes. Wright-Patterson is modeled alone because it was used as the initial model to test the feasibility of the modeling approach. Because of the limitation of the microcomputer version of the language, the system is broken down further into sizes that run on the ARFCOS computer. A complete listing of the SLAM II code for the six models can be obtained by contacting Major William Rowell, AFIT/ENS, Wright-Patterson Air Force Base, Ohio 45433 (VMS Tape 197). The individual models have been given to ARFCOS/TR, Ft. Meade Md. on standard 5 1/4 inch double sided, double density disks for the Zenith Z-100 microcomputer.

Model Formulation

Each modeled station was contacted and interviewed on their route structure, the normal duty day manning procedures, the amount of travel time each leg of each route took, the amount of time spent at each point along each route, their current manning, and other pertinent information. Although the amount of time spent preparing, traveling, or serving customers is, in reality, a random variable, it is modeled as a fixed interval. This simplification is made because the couriers interviewed said their overall return to station time is relatively constant; they almost always plan on returning by a specific time.

The amount of material picked up or delivered to the points is treated as a random variable. Instead of using the historical data and using table look up procedures to determine the weight to be delivered or picked up, probability distributions based on the historical data are used. Three advantages of using probability distributions are: it allows modeling of expected future performance, instead of replicating the past; it is more efficient use of computer time; and it allows sensitivity analysis to be performed on how critical the assumed distributions are to the results of the model (20:27-8). The manner in which the distributions were derived and tested is discussed in Chapter II. A listing of the points by serving ARFCOS is in Appendix A.

Model Translation

This section explains a section of the SLAM II code used to implement the model. Recall an entity represents whatever the modeler wants. An entity either flows though the network, or else causes something to happen which affects the state of the system. Attributes are unique characteristics given to entities. Networks are made up of nodes and branches. Branches are used to represent activities, or the passage of time, and nodes serve as connectors between branches. Entities come into being at CREATE nodes, and perform their functions at ACTIVITY branches.

The June 1985 route structure was translated into a SLAM II network. A route, or a duty day, is the network through which the entities flow. A common time standard of 00:00.0 on an even Julian Sunday morning is time zero in all models. For ease of modeling, all weeks have 168 hours, and each month has four weeks. No month has a holiday. Routes that are run on odd Julian Wednesdays, for example, are started 336 hours apart, and Ø6ØØ on that Wednesday would start at time 78.

The following SLAM II code represents the McGuire ARFCOSTA route serving Ft. Dix and McGuire AFB.

```
 1.      CREATE,168,128,1;          CREATE AN ENTITY
 2.      AWAIT(3),MG9/1;      GET 1 FORM 9
 3.      AWAIT(4),MG14/1;     GET 1 FORM 14
 4.      ACT,Ø.5;             PREPARATION TIME
 5.      ASSIGN,ATRIB(2)=UNFRM(Ø,.6),4
 6.      ASSIGN,ATRIB(3)=BETA(.9926,1.Ø39)*.33/4;
 7.      ASSIGN,ATRIB(4)=ATRIB(2)+ATRIB(3);
 8.      ASSIGN,XX(2)=XX(2)-ATRIB(4);
 9.      ACT,,,MG;
10.      ACT,1.Ø;          DRIVE TO ACCOUNT
11.      ASSIGN,ATRIB(4)=ATRIB(4)-ATRIB(2);
12.      ASSIGN,ATRIB(2)=UNFRM(Ø,.5)/4;
13.      ASSIGN,ATRIB(4)=ATRIB(4)+ATRIB(2);
14.      ACT,,,MG;
15.      ACT,.5;     SERVE ACCOUNTS
16.      GOON;
17.      ACT,1.Ø;          DRIVE TO ACCOUNT
18.      ASSIGN,ATRIB(4)=ATRIB(4)-ATRIB(3);
19.      ASSIGN,ATRIB(3)=UNFRM(Ø,.5)/4;
20.      ASSIGN,ATRIB(4)=ATRIB(4)+ATRIB(3);
21.      ACT,,,MG;
22.      ACT,.5;          RETURN TO AFCOSTA
23.      ASSIGN,XX(2)=XX(2)+ATRIB(4);
24.      ACT,.75;     CLEAN UP PAPERWORK
25.      FREE,MG9/1;
26.      FREE,MG14/1;
27.      TERM;
28. MG   COLCT(8),ATRIB(2), LOCAL DELIVERY CAP;
29.      TERM;
```

Line one causes an entity to be created at time 128, and every 168 hours (one week) thereafter. This represents the time the courier(s) would show at the station to begin preparing for a trip. The time the entity is created is stored in attribute one. The entity is used to represent the vehicle used to serve the accounts. The entity goes sequentially through the two AWAIT nodes, where one unit of the resources representing couriers and assistant couriers, named MG9, and MG14, respectively, are waited for. The entity should not spend any time waiting. If any time is spent waiting then that is indicative of a manpower shortage; it is time to serve customers on a route, and no one is available to do it. SLAM II keeps statistics on resource use; maximum and minimum numbers used at one time, average numbers in use, time waiting for a resource to be freed, and other pertinent data are automatically tracked. Some stations showed a maximum number of people in use at one time equal to their total number of personnel. This indicates potential problems in cases of sicknesses, training requirements, and other planned or unplanned absences.

Line four represents the total amount of time the couriers spend preparing to serve the accounts on this route, the time involved in loading the vehicle and preparing paperwork.

Lines five through seven assign the entity unique characteristics. The assignment node assigns to attribute two a value equal to one quarter of a random variable from a uniform distribution with a minimum value possible of zero and a maximum value of .6 (600 pounds). The random variables represent the amount of material to be delivered to Ft. Dix. Attribute three represents the amount to be delivered to McGuire AFB. The value in attribute four represents the total material weight in the vehicle. On longer routes more attributes are used with each succesive attribute representing a single location along the route. The last attribute for each route is the sum of the weights for all locations. It is this sum which represents the total weight in the vehicle.

The total material weight in the simulated vehicle is subtracted from the amount on the floor at the ARFCOSTA in line eight . When an entity leaves a node it may take as many activities as the modeler desires. If two or more activities follow a node then exact copies of the entity are made and sent down each branch. In this instance, the two activities following the node cause a duplicate vehicle to be created. One is sent to a collection point at line 25, labeled by MG, where the weight in the attribute representing the total weight in the vehicle is collected. After passing through that collect node, this entity is terminated, or destroyed. The other entity goes to its first point on the route, and takes one time unit (in this case, one hour) to do it.

Lines 11-13 represent what happens to the vehicle when it arrives at its first destination. When the vehicle arrives at the location, the weight to be delivered to that location is subtracted from the total in the vehicle. Next, a random variable representing the amount picked up from the location is determined, and assigned to the attribute representing that location. That weight is then added into the total vehicle weight, representing a pickup.

Lines 14 and 15 are activities, so again the entity is duplicated and sent down both paths -- one to the collect node, where the value of the attribute representing the total weight in the vehicle is collected, and the other continuing through the route.

Line 16 functions solely as a connector between two activites.

Line 17 represents driving to the account. Lines 18-20 represent serving the account; the process of subtract the delivered weight, determine the weight to be picked up, and add the picked up weight into the vehicle is accomplished. After every consolidated point, an entity is sent to the collect node where its weight is taken. SLAM II provides minimum, maximumm, average, and standard deviation figures on the weights.

When the entity arrives back at the station (line 23) its weight is added into the amount on the floor at the station. SLAM II, again, provides statistics on these values. The entity is then terminated.

All of the routes are variations on this theme. In instances where the historical data indicated either almost no weight for eleven months of the year, and one month had a significant amount, probabilistic branching was used to route the entity through different assignment nodes, one which reflected the eleven month distribution, and a constant for the large amount.

Model Validation and Verification

"Model validation is the process of bringing to an acceptable level the user's confidence that any inference about a system derived from the simulation is correct" (20:29). Verification is the process of insuring that the model behaves in the manner the experimenter intends (20:30). Both were accomplished to increase ARFCOS' acceptance of the model.

Verification. Verification of the model was accomplished by careful line by line reading, comparing what was intended to be in the code with what was actually in the code, analysis of the results of the runs, and use of embedded error detecting routines within SLAM II.

SLAM II was used to find any syntax errors, misplaced commas, and other common errors. Desk checking, comparing what is actually in the model to what was supposed to be in the model, was done to guarantee the accuaracy of the output. Every line was examined for agreement with the desired model.

Analysis of the runs unearthed subtle errors. For example, an error in logic was found when queues for the couriers started to form. When no queus formed, and when no errors where encountered in execution, the model was verified.

Validation. Validation of the models was accomplished by calling the appropriate courier station, and comparing the model's maximum capacity required figures, to the courier's estimates concerning the maximum capacity. The validity of the route totals is dependent on the validity of the distribution data. The distribution data, which was determined by an analysis of primary data sources, was assumed to be valid.

In cases where the model's data were significantly different from the courier's estimates, further research was conducted to resolve or explain the differences. In some instances the problem was with the limitations of the vehicle being used to accomplish a route. At Norfolk, the vehicle used to serve Ft. Bragg and Pope is a small airplane. The limitation of the airplane requires that they not pick up, or deliver all of the material for that location. Between two and four times each month they take a truck and deliver all of the overflow from the airplane to Ft. Bragg and Pope. What the model tells them is what vehicle capacity would be required if they wanted to deliver all of the material expected. In no case was there an unexplainable difference between the models' output and the couriers' estimates of the same route.

This is taken as strong evidence for the validity of the model. Validity is built into the model by design. The model is written based on what the couriers say they do, what distributions are shown by primary data to be reasonable, and the actual route structures. Validity was examined after completion by comparing the results of the model to the actual data of the ARFCOS system.

Strategic and Tactical Planning

Strategic planning, as it applies to the simulation process, involves the designing of experiments that will yield the desired information. Tactical planning involves answering questions of efficiency, and deals with determining how each test run specified in the strategic plan is to be executed (20:30-31).

This thesis builds the models to be used to assist with corporate strategic planning. The information desired from the models is the expected maximum weight along each of the routes. Simulation is the appropriate manner to determine those weights because each point along the route has a different demand distribution, and the ways of analytically determining an expected value when combining many different distributions are not well defined. Now that the distributions are known, alternative routes can be built and analyzed to calculate expected capacity requirements.

The strategic plan consisted of running the model to determine manpower utilization rates and required vehicle sizes. Differences between different models or parameters is not an issue in this thesis so varying any of the conditions is not needed.

The tactical plan consisted of running the model for 17472 hours (26 months), clearing all of the statistics after each 672 hours (one month). Since monthly demand for every point was assumed to be independent, this gave 26 samples of maximum vehicle loading during the month. Twenty six months was chosen because of the tradeoffs between desired accuracy, available computer time, and available data analysis time. The more accurately one desires to estimate the population, the more samples one needs to take. A sample size of twenty six was assumed to be adequate so as to invoke the central limit theorem.

> It is usually sufficient that the response is the additive sum of a large number of contributing effects. This allows us to assume that the response variable. . . will be normally distributed (20:187).

This sample size allows the parameter of the maximum expected weight for a route during the month to be estimated to lie within the standard deviation of the maximum values divided by 2.6 with 95% confidence. (See appendix B) For example, if the mean maximum is found to be 700 pounds, with a standard deviation of 200 pounds, then the 95% confidence interval for the true mean maximum is 700 plus or minus 77. The standard deviation of the maximum values, of course, is likely to be different for each of the routes.

Experimentation

Because time is modeled as a constant each month's output of manpower utilization rates is the same. Experimentation is done with the San Diego, Kelly, and Wright Patterson models by changing the route structures, and varying the amount of time involved in completing a route The routes of the Wright-Patterson ARFCOSTA are such that it was easy to change the times traveled from one point to another to allow for faster travel in an airplane. This was done to test the reasonableness of varying the enroute times, to see if any useful information could be obtained from the manpower statistics.

Interpretation

Interpretations of the models' results are discussed in Chapter IV, Analysis of Results.

Implementation

Implementation is up to the managers at ARFCOS. An attempt has been made to produce a model which meets the needs of managers, one which is relevant, valid, usable, and cost-effective. Relevant in that it deals with a problem which they consider important; valid in that they can place confidence in the inferences drawn from it; usable in that it is easy to modify to ask other types of questions; and cost-effective in that it is inexpensive to change the model and run on their equipment, with potentially large savings from the insights into locating stations and manpower that it can provide (20:252).

Documentation

The models are provided in two forms: one to be run, and one to be read. Due to limitations of the MS-DOS SLAM II, the heavily documented code which was originally written makes the models too large to run on the microcomputer. Therefore the models were "de-documented" to run. ARFCOS has all of the documentation on the language, the instructions on how to run the models, and an example of how to interpret the results of the models.

IV. ANALYSIS OF RESULTS

Introduction

This chapter summarizes the results of the simulations and describes the conclusions drawn by the researchers based on their analysis of the simulation model's output and their knowledge and experience gained through the detailed study of the ARFCOS system. Each of the 14 modeled CONUS stations is discussed individually. However, the discussions, and some of the recommendations made, involve the merger of two or more stations' routes and customers. It is important to note that the conclusions and recommendations presented are the results of the researchers' study. They are presented as alternatives to the way ARFCOS currently conducts business. ARFCOS management may have overriding considerations that prohibit the use of some of the ideas; for example, high customer service levels may be more important than the efficiencies which can be gained by making more customers come to the station. Further research, including benefit/cost analysis, needs to be performed before taking or dismissing any management action to implement any suggestion(s) discussed here.

The first section of this chapter summarizes the results of the research effort and reviews the general research questions answered by this study; the next section covers each station individually. The final section presents the results of the analysis.

Summary of Research

Six simulation models representing the 14 CONUS stations were developed, verified, analyzed, and validated to accurately portray the distribution network of the Armed Forces Courier Service. The outputs of 71 routes were analyzed to determine the required weight bearing capacity of the serving vehicle; approximately 365 separate demand points were analyzed for each's underlying distribution. Two of the ARFCOSTAS, Wright-Patterson and San Diego, are modified to examine the result of alternative methods of operation on manpower utilization.

Specific research questions set forth in Chapter 1 include:

1. Where are the sources and final destinations of the cargo?

a. How much weight is picked up and delivered at each point?

b. How frequently is each customer served?

2. How much manpower is required to provide the current service by the present system?

a. How many separate trips are required to satisfy all demand?

b. What service method (air or ground) is employed?

These questions are designed to guide the research effort toward answering the questions:

1. What weight bearing capacity must the vehicle have for each of the various routes?

2. Can any stations be consolidated and still meet customer needs and security requirements?

Distribution Considerations

Appendix A lists all the analyzed consolidated pickup and delivery points' means, standard deviations, and distributions used in the model. The weights are in thousands of pounds. They are listed in alphabetical order by serving ARFCOSTA. Some points have more than one distribution listed for the same direction. Under Charleston, for example, Montgomery is listed:

ACCOUNT	CURVE	MEAN	S.D.	ALPHA	BETA
MONTGOMERY.IN	WEIBULL	.218	.079	3.018	.244
MONTGOMERY.OUT	WEIBULL	.04	.052	.7785	.0344
MONTGOMERY.OUT	8% = .735				

Montgomery.in represents the amount to be delivered to Montgomery, and Montgomery.out, the amount to be picked up. The two Montgomery.out listings occur because of the disparate nature of one of the months' pickup. One month out of the year's pickups from Montgomery resulted in 735 pounds of material. The other eleven months averaged 40 pounds. No single distribution tested provides the range of outputs required to model this distribution. Because the model is intended to capture the extreme values, the point is modeled as two distinct distributions. Approximately 92% of the values randomly generated for the amount to be picked up from Montgomery will come from the weibull distribution. The remaining 8% will be a fixed 735 pounds.

Manning Considerations

Couriers are E-6's and above; they are referred to as Form 9's because of the form number of their identification card. Form 14's are assistant couriers and are below the rank of E-6. Only Form 9's may receive or dispatch material. Assistant couriers act as administrative specialists, vault workers, drivers, and guards. A courier can always substitute for an assistant, but not vice versa (12).

In computing an average utilization factor for the couriers and assistant couriers, all time spent working in the office or away from the office on the road is included. All the time the person spends on the road is time not available for other work, so it is not unreasonable to count the entire time gone as a single shift (12). By working five shifts out of the 21 possible every week (three shifts per day) the utilization rate for one person is 0.238. When annual leave is taken out of the time available, the average expected utilization rate drops to 0.194. Training, sickness, and personal problems further decrease the expected average use rate. At Air Force stations, unlike Army and Navy stations, the personnel are still eligible for professional training, like NCO Leadership School and the Senior

NCO Academy, which require extended time away from the station.

ARFCOS has no standard against which to judge utilization rates. Additionally, a high rate is not necessarily the sign of an overtasked station; it could merely reflect inadequate management of the current manpower. The numbers for average utilization would drop as the number of trips requiring couriers to stay overnight along the route dropped and increase as the models were adjusted to allow for leave, professional schools, and other demands on peoples' time. This thesis establishes 0.19 to be the standard individual utilization for comparison, and uses this standard to make approximations of the required manpower for the ARFCOSTAS by dividing the average utilization by 0.19.

Another factor, treatment of local accounts, plays an important part in determining utilization rates. If all customers within 50 miles of an ARFCOSTA were required to come to the station to pick up or deliver material, then the station would not have those local routes to deliver. Whether the customer comes to the station, or the station goes to the customer, is a function of the importance of the customer and the manning of the station. One way of keeping couriers busy is to send them around the local area distributing and picking up material.

Each station sets its own duty day and manning. Some stations operate from 0700-1530, others from 0730-1700, and some for 24 hours per day. Some stations have two couriers in the storage facility preparing the next day's deliveries, while other stations have the couriers, who are actually going to make the deliveries, come in the day prior to put their own material together. The effect of changing from the latter to the former is discussed in a later section of this chapter.

Finally, special trips are made to deliver material which exceeda the capacity of the normal delivery vehicle or needs to be expedited to meet deadlines. Because these trips have not been included in the model, the actual utilization rate of couriers at stations with a large number of special trips should be higher than indicated by the modeled results. Obviously, those stations which most completely described their operations are the most accurately modeled. A low utilization factor for a station is not necessarily indicative of underworked people. It may be the result of inadequate detail. This, coupled with the lack of standardization, makes it unreasonable to compare rates between stations or to say anything meaningful about how efficiently the stations are being managed. The utilization rate for a single station serves as a basis for comparison to that same station modeled under different work policies; it provides the "before" for a "before" and "after" comparison.

Table I summarizes the manpower use modeled for each

Table I

Courier Utilization

RESOURCE NAME	CAP	REQ	AVE UTIL	S.D.	MAX UTIL	AVE AVAIL	IND UTIL
BO09	6	6	1.05	1.406	4	4.95	.18
BO14	5	6	1.05	1.406	4	3.95	.21
CH09	7	5	.83	1.028	4	6.17	.12
CH14	5	4	.69	1.055	3	4.31	.14
DE09	5	4	.67	.956	3	4.33	.13
DE14	3	3	.44	.767	3	2.56	.15
DO09	7	3	.46	.812	3	6.54	.07
DO14	5	3	.46	.812	3	4.54	.09
JA09	5	5	.91	.992	4	4.09	.18
JA14	5	6	1.14	1.376	4	3.86	.23
KE09	13	8	1.41	1.839	7	11.59	.11
KE14	9	7	1.17	1.671	6	7.83	.13
LA09	4	4	.76	1.167	3	3.24	.19
LA14	4	3	.51	.766	2	3.49	.13
MC09	4	4	.63	.853	4	3.37	.16
MC14	3	4	.63	.838	3	2.37	.21
MG09	3	3	.53	.911	3	2.47	.18
MG14	3	3	.53	.911	3	2.47	.18
MGCIV	1	2	.24	.426	1	.76	.24
NO09	7	9	1.65	.874	5	5.35	.24
NO14	7	8	1.43	.767	4	5.57	.20
OF09	5	7	1.25	1.131	4	3.75	.25
OF14	5	3	.45	.593	2	4.55	.09
SD09	9	6	1.00	1.236	4	8.00	.11
SD14	9	6	1.09	1.610	5	7.91	.12
TR09	12	12	2.30	1.183	6	9.70	.19
TR14	9	9	1.63	.829	5	7.37	.18
WPCOUR	15	11	2.09	2.617	8	12.91	.14

station. The "RESOURCE NAME" column is the name given the resource within the models. The prefix (two characters) is the abbreviation for the ARFCOSTA location and the designator "09" or "14" is used to differentiate the couriers from the assistant couriers for all stations except Wright-Patterson. The "CAP" column is the number of personnel assigned in that capacity. The "REQ" is the number of personnel for which the researchers' standard calls to be adequately manned. It is computed by dividing the AVE UTIL by .19 and rounding any decimal over .1 to the next higher number. "AVE UTIL" is the average number of people working at any time in the station; the "S.D." is the standard deviation of that average. "MAX UTIL" is the maximum number of people working at one time. The average available (AVE AVAIL) is the average number of people who are not working at any time, which is the difference between columns CAP and AVE UTIL. The "IND UTIL" is the individual utilization. It is determined by dividing the average utilization by the number of people (CAP).

Distribution of Maximum Weights

The maximums from the 26 months run are distributed normally; the data sets were analyzed using the AID software package described previously. Tables II to XV summarize the local routes for each of the ARFCOSTAS. The mean maximum is the arithmetic mean of the maximum weight in the vehicle for each of the 26 months, expressed in thousands of pounds. The 90, 95 and 99 percent figures are weights which will not be exceeded with 90, 95 and 99 percent confidence, respectively. They are determined by multiplying the standard deviation of the means by 1.282, 1.645, and 2.33 and adding to the mean. These weights represent the vehicle weight bearing capacity needed to serve that route. For example, reference Table II, Route North 95, the average maximum weight in the vehicle at any one time is 1,660 pounds. The standard deviation from that average is 700. With 90, 95, and 99 percent confidence, vehicle weight bearing capacity will not exceed 2,560, 2,810, and 3,310 pounds, respectively.

Station Conclusions and Recommendations

Boston Results. Boston ARFCOSTA is commanded by a Chief Warrant Officer and operated by Navy personnel. Boston is assigned six couriers and five assistant couriers. The 9's and 14's both have an overall utilization rate of 1.05, and an average per individual rate of .18 and .21 respectively. At no time are more than four couriers and four assistant couriers required.

All of Boston's CONUS routes are served by ground transportation. Boston serves most of New England. Its routes serving CONUS accounts extend northeast to Maine, west to Syracuse and Fort Drum NY, and south to New London, CT. It connects with other ARFCOSTAS by driving to McGuire or Dover and exchanging material bound for Washington for material bound for the Boston customers. Figure 2 depicts the service area and major routes of the station. Table II summarizes the five modeled routes.

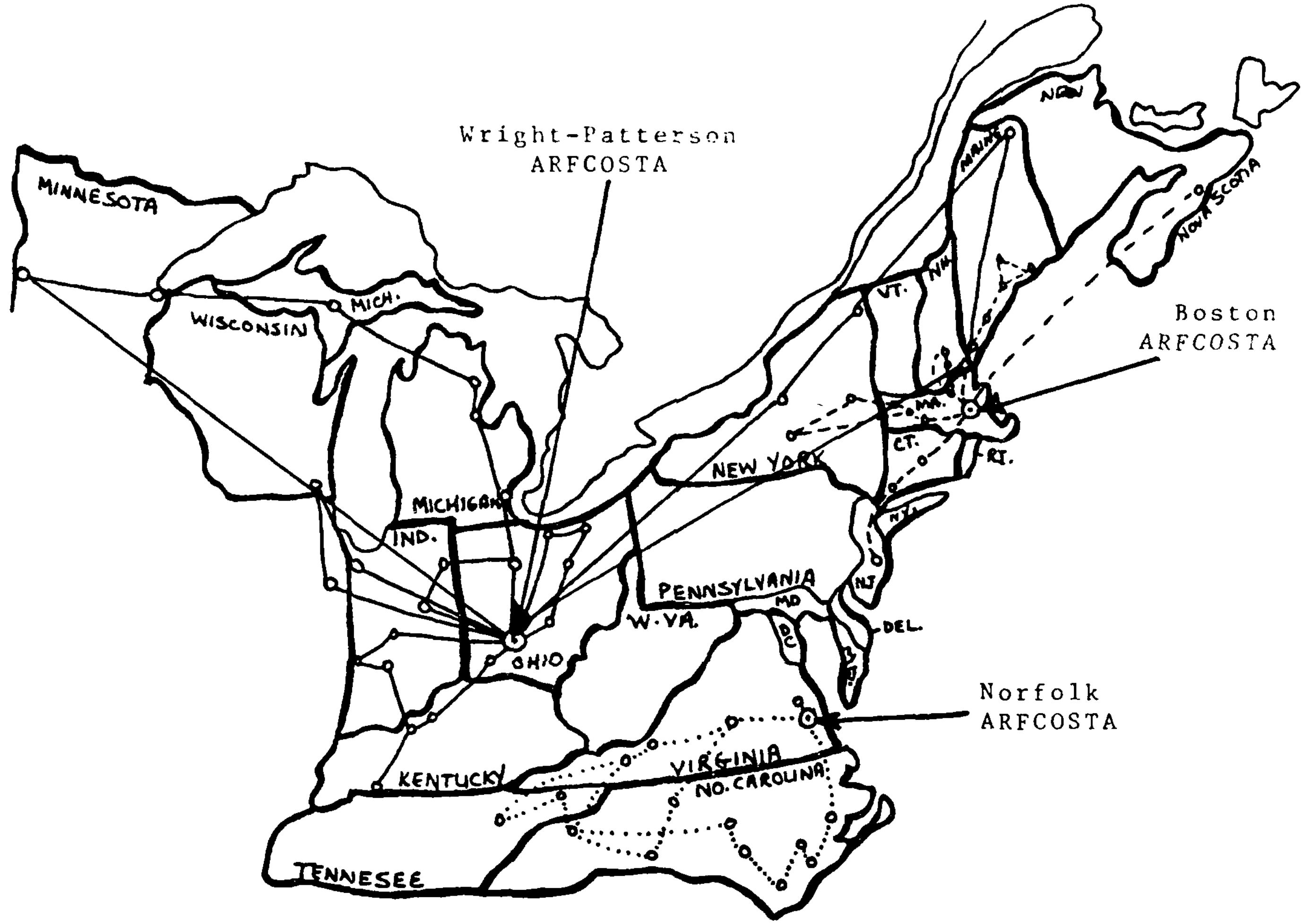

Fig 2. Boston, Norfolk and Wright-Patterson ARFCOSTA Service Areas

TABLE II

Boston Route Summary
(in thousands)

ROUTE	MEAN MAX	S.D.	90	95 REQ. CAP.	99
DRIVE WEST	.25	.04	.30	.31	.34
NORTH 95	1.66	.70	2.56	2.81	3.31
NASHUA	1.52	.43	2.07	2.22	2.53
DOWNTOWN	.58	.19	.83	.90	1.04
NEW LONDON	.92	.20	1.18	1.26	1.40

The routes which require an overnight stay away from home are the Drive West to Syracuse and the North 95 into Maine. The Downtown run serves customers that are within 50 miles of the ARFCOSTA. Boston's largest customers are New London, CT, Ft. Devens, MA, and Brunswick, ME, which account for over half of the total weight picked up and delivered.

Recommendations. The Drive West route is suitable for a small airplane contract. Its weight requirements are low, and it could be flown in one day, thus saving per diem payments for the time away from station, and increasing the couriers' availability. It could easily be flown out of McGuire or Dover, instead of Boston, and included in their route structure and small airplane contracts. ARFCOS should investigate the ramifications of such restructuring. They should use the model to determine the effects of alternative service policies (having the local accounts come to the ARFCOSTA) and alternative routes on utilization rates.

Charleston Results. Charleston SC ARFCOSTA is commanded by an Air Force Captain and manned by USAF personnel.

Charleston, SC has seven couriers and five assistants. Charleston uses truck, LOGAIR, Military Airlift Command (MAC), and small air taxi to serve their customers. As can be seen from Figure 3, their routes serve areas including South Carolina, Georgia, and points west as far as Blytheville, Arkansas. In addition to the routes listed in Table III, Charleston also serves Ascension Island. The largest customers are the local Navy Base, the over the counter service, and Fort Stewart, GA. The weights reflected for CHS RT 2 and Memphis are the needed vehicle capacities to serve the routes as scheduled. The airplane used to serve these routes does not have the required capacity, resulting in additional trips. Truck trips to the large accounts are required to carry the overflow. These special trips due to their unscheduled nature, are not reflected in the model, thus the modeled manpower utilization rates of .12 and .14 are lower than the actual rates.

TABLE III

Charleston Route Summary
(in thousands)

ROUTE	MEAN MAX	S.D.	90	95 REQ. CAP.	99
CHS RT 2	4.37	.69	5.26	5.51	6.00
MEMPHIS	2.68	.26	3.01	3.11	3.39
LOCAL	1.38	.26	1.71	1.81	1.99

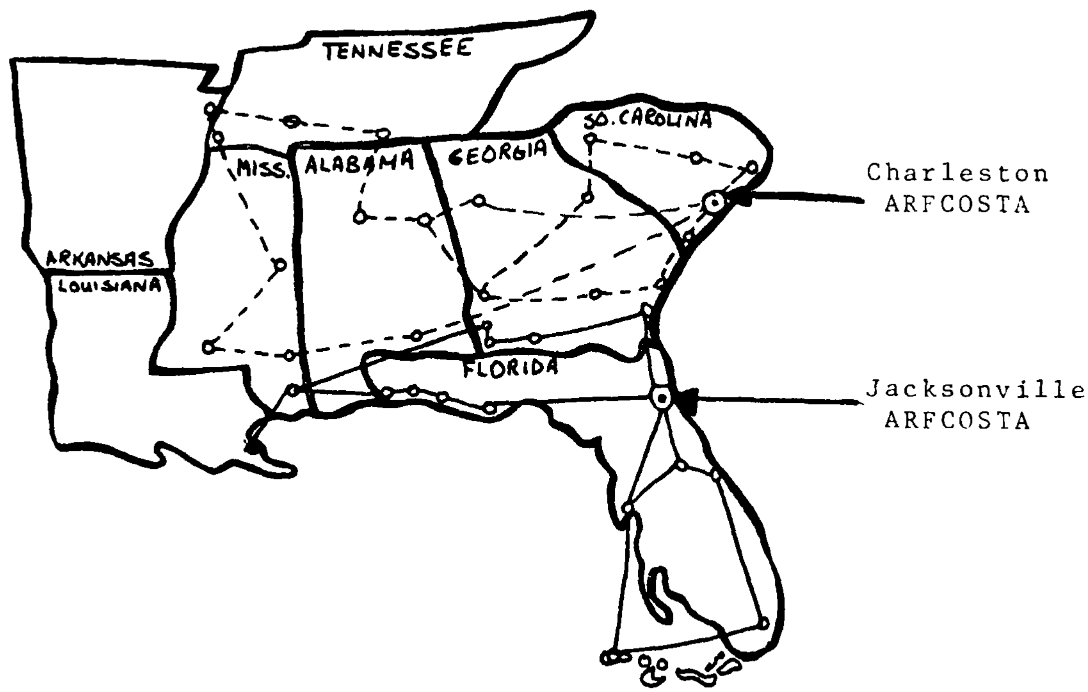

Fig 3. Charleston and Jacksonville ARFCOSTA Service Areas

Recommendations. ARFCOS should investigate using small air taxi flights out of Norfolk and Jacksonville to serve the current customers of Charleston.

Denver Results. Denver CO ARFCOSTA is commanded by an Air Force Major and manned by USAF personnel, with five couriers and three assistant couriers. Denver's utilization

Table IV

Denver Route Summary
(in thousands)

ROUTE	MEAN	MAX	S.D.	90	95 REQ. CAP.	99
WINNIPEG	.1Ø		.Ø1	.18	.21	.25
COLO SPNGS	7.ØØ		3.53	11.52	12.8Ø	15.35
SALT LAKE CITY	.38		.Ø6	.45	.47	.51
F E WARREN	.25		.31	.65	.75	.99
DENVER	1.31		.22	1.53	1.66	1.82

factors of .13 and .15 are close to the sytems' average of Ø.152. Denver operates truck routes and uses commercial airplanes to serve its customers. It serves primarily Colorado, North Dakota, Utah, and Wyoming with with its major customers being Colorado Springs, Buckley Field, and Fort Carson. (See Figure 4) Denver's interactions with other ARFCOSTAS are weekly flights to Ft. Meade and from Kelly. The ARFCOSTA is located in Denver instead of at Colorado Springs with its major account (Space Command) because of the major airport at Denver which allows convenient access to the commercial airplanes. It is the newest station, opening less than two years ago. As Space Command matures,

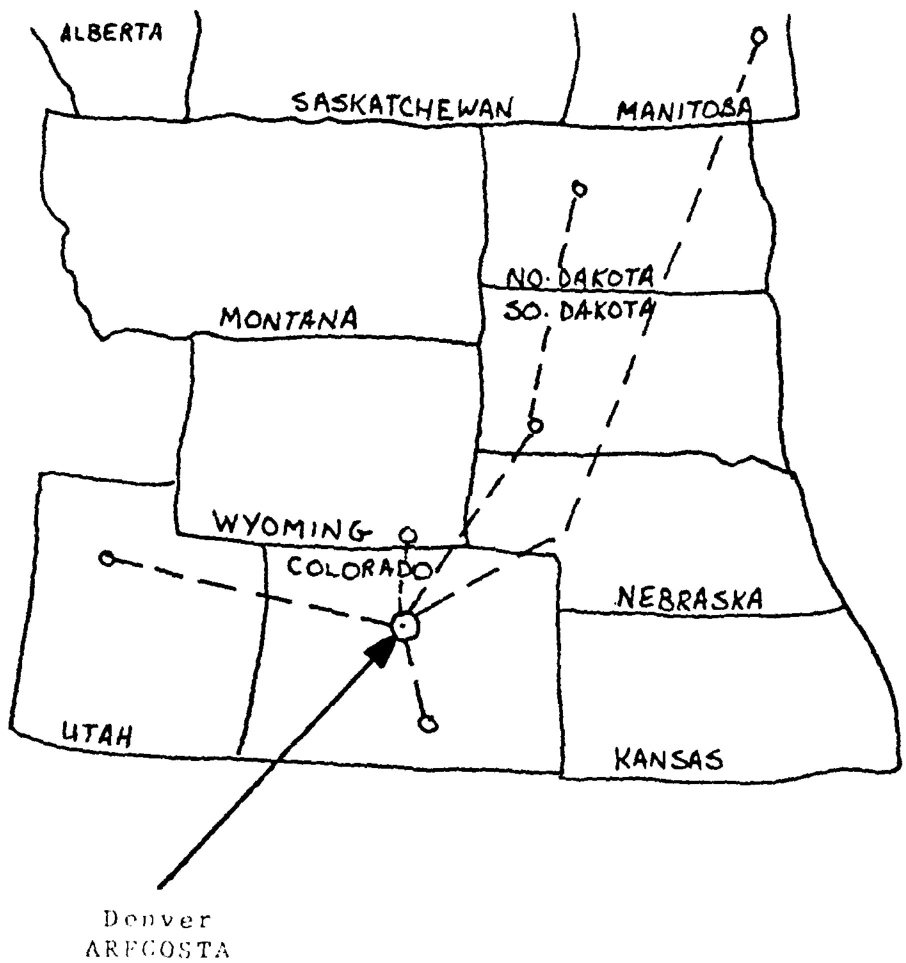

Fig 4. Denver
ARFCOSTA Service Area

Denver's business will increase in volume and number of accounts.

Recommendations. As can be seen from figure 4, Denver is located centrally for its customers and is at a major transportation hub. The researchers have no specific recommendations for further research for Denver ARFCOSTA.

Dover Results. Dover ARFCOSTA is located at the largest aerial port in the USAF. The station is commanded by an Army Captain and operated by USA personnel. Its seven couriers and five assistants support two weekly air taxi routes, and a twice weekly truck trip to Ft. Meade. The air taxi operations support Pennsylvania, New York, and Connecticut customers. Figure 5 depicts the routes and service area. Its manning utilization factors of 0.07 and 0.09 are among the lowest.

TABLE V

Dover Route Summary
(in thousands)

ROUTE	MEAN MAX	S.D.	90 REQ. CAP.	95 REQ. CAP.	99 REQ. CAP.
DOVER RT 2	.50	.19	.74	.81	.94
DOVER RT 3	.80	.24	1.10	1.18	1.35

Recommendations. If, as the researchers have been led to believe, the primary purpose of maintaining an ARFCOSTA at Dover is to have access to the aerial port in case of a crisis, then the station is fulfilling a readiness

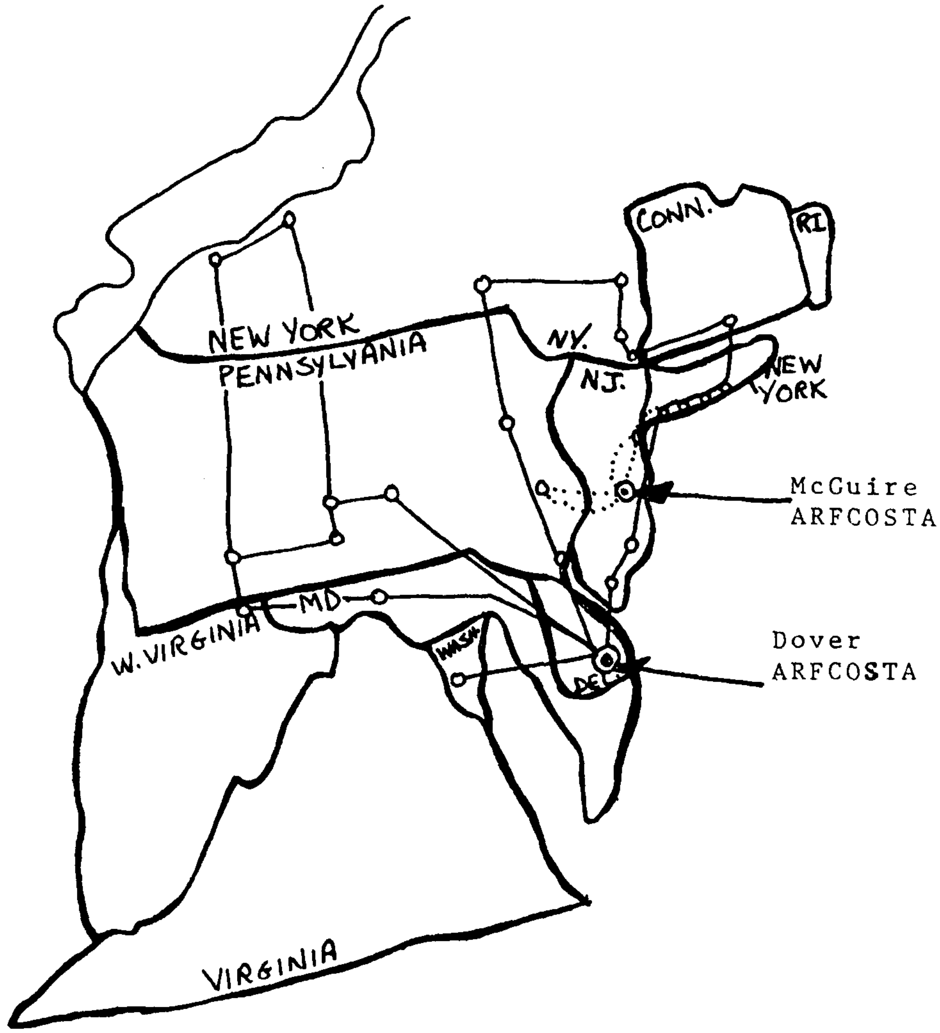

Fig 5. Dover and McGuire ARFCOSTA Service Areas

function which another station cannot (12). Aside from this requirement, McGuire, which is also a major MAC aerial port could absorb all Dover's accounts, with the air taxi routes being flown out of McGuire and the local accounts served by truck or small airplane. Maintaining both of the stations is costing ARFCOS a minimum of two people in overhead because all stations have a minimum of two people working within the station during normal duty hours (12). ARFCOS should build models of a system which has only one station in the area. The customers should be reallocated, new service routes computed, and the resulting system analyzed. The accounts of Dover, McGuire, and Boston should all be considered in the reallocation.

McGuire Results. McGuire is a USAF operation; it is manned by three couriers and three assistant couriers. The manpower utilization rate of .18 is quite high. This station serves New York City, Philadelphia, and New Jersey by ground transportation. The couriers also fly to Iceland and the Azores. None of the local account service requires an overnight stay away from home. Its largest customers are Camden, NJ, the Naval Ship Yard in Philadelphia, and Downingtown, PA. Figure 5 shows the area served, and the major routes.

TABLE VI

McGuire Route Summary
(in thousands)

ROUTE	MEAN MAX	S.D.	90	95 REQ. CAP.	99
ROUTE 2	.57	.24	.87	.96	1.12
ROUTE 3	6.38	1.43	8.21	8.73	9.72
ROUTE 4	.16	.04	.21	.22	.24
ROUTE 5	.43	.15	.61	.66	.76

Recommendations. As is discussed in the section on Dover, the Dover and McGuire stations could be combined. Furthur research should be made into the trade-offs involved in having access to Dover's aerial port, which has more flights into Europe and the Middle East versus McGuire's proximity to the numerous New York City area accounts.

Jacksonville Results. Jacksonville, FL ARFCOSTA is a Navy station commanded by a Chief Warrant Officer (CWO4). Its five couriers and five assistant couriers, with utilization rates of .18 and .23, are among the busiest in the system. Located at the Jacksonville Naval Base, this ARFCOSTA moves much of its material via the Navy QUICKTRANS system, which is a regularly scheduled logistics support cargo system supporting Navy facilities throughout the United States. The remainder of Jacksonville's customers are served by truck and small airplane taxi services. The service area is primarily all of Florida with customers as far west as New Orleans, LA. The service area and routes are depicted in Figure 3.

TABLE VII

Jacksonville Route Summary
(in thousands)

ROUTE	MEAN MAX	S.D.	90	95	99
			REQ. CAP.		
HONEYWELL	4.94	1.18	6.46	6.88	7.74
KEESLER	1.23	.26	1.56	1.66	1.84
FLORIDA	18.94	.58	19.69	19.90	20.32
MAYPORT	.55	.05	.62	.64	.68

In addition to the routes listed in Table VII, the local and over the counter customers add about 5000 pounds of demand to the station.

Recommendations. Due to the proximity to Charleston and the parallel nature of their western routes, further study should be done on combining Charleston's and Jacksonville's operations at Jacksonville. The daily operations at Jacksonville are radically different from all the other ARFCOSTAS. No other station routinely schedules their vault workers and duty couriers to work until all material brought in on that day's runs are processed. Additional research should be accomplished to determine if the high utilization rates seen at Jacksonville are more the result of overtasking, or inefficient use of resources. At least two additional men are needed to bring the individual utilizations rates down to the standard using the present operating procedures.

Kelly Results. Kelly ARFCOSTA, located at Kelly AFB, TX is the second largest courier station. Kelly is commanded by an Air Force Captain and manned by USAF personnel consisting of 13 couriers, and nine assistant couriers. The utilization rates of .11 and .13 are among the lowest, but this is due to the manner of modeling the daily operations. The largest customer of the Kelly station is the Air Force Crytpological Support Center at Kelly. This facility averages over 50,000 pounds in and out every month.

Kelly, with a service area including Texas, Oklahoma, Louisiana, Arkansas, and New Mexico, serves its accounts by air taxi, truck, and LOGAIR. Figure 6 depicts the major routes and service area.

TABLE VIII

Kelly Route Summary
(in thousands)

ROUTE	MEAN MAX	S.D.	90	95 REQ. CAP.	99
TINKER	3.11	.79	4.12	4.41	4.99
KIRTLAND	1.84	.43	2.39	2.54	2.85
CORPUS	.06	.02	.09	.10	.11
ROUTE 5	1.70	.44	2.27	2.43	2.75

Kelly also makes connections between many of the ARFCOSTAS, with weekly runs to Wright-Patterson on its way to Washington, Travis, and Denver.

Recommendations. Kelly is conveniently located on the LOGAIR routes, and should be given the customers at Phoenix, and Tucson, Arizona. Currently, San Diego serves

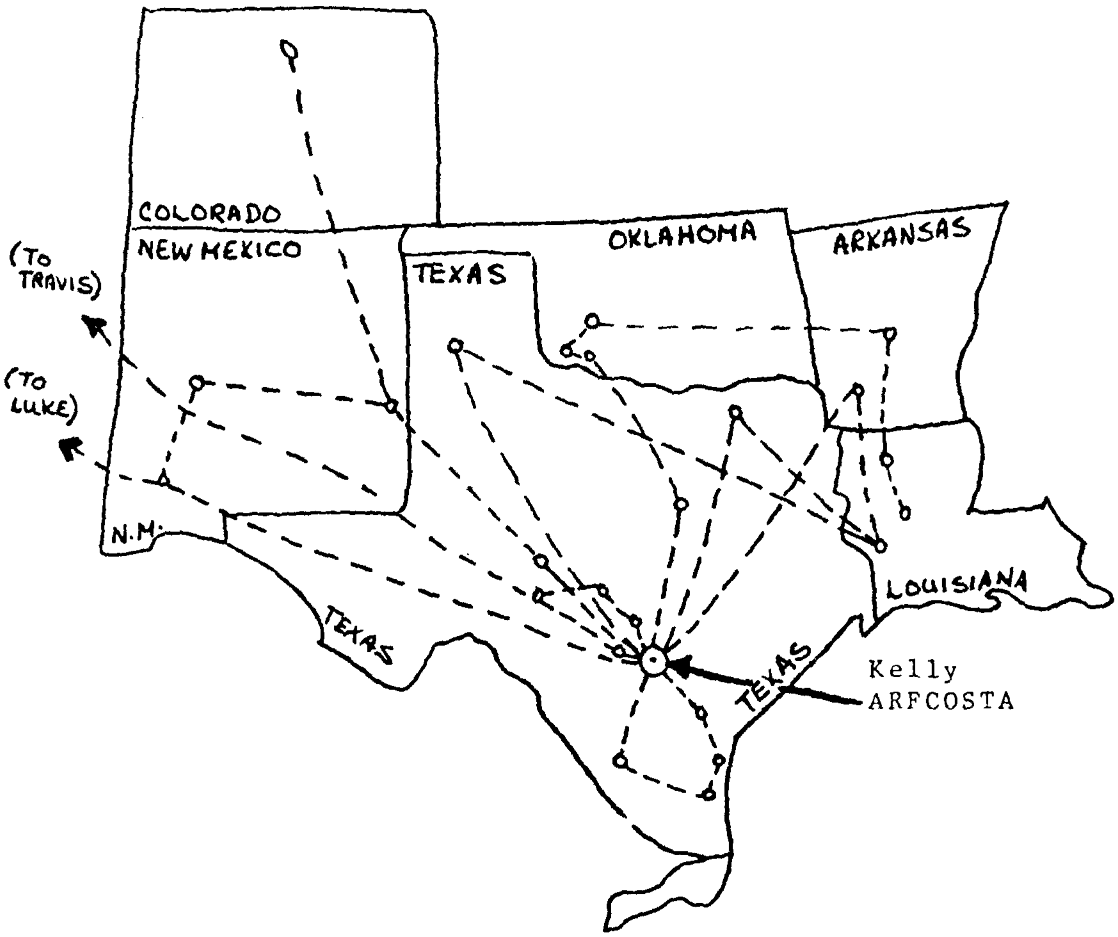

Fig 6. Kelly
ARFCOSTA Service Area

Luke and Scottsdale at Phoenix, and Davis Monthan AFB and Ft. Huachuca at Tucson on a three day road trip. Kelly couriers are on the ground at Phoenix during the LOGAIR flights, but do not serve any accounts there.

Los Angeles Results. The Los Angeles ARFCOSTA is commanded by a Navy Warrant Officer and manned by eight Navy personnel. The four couriers and four assistant couriers are used at a 0.19 and 0.13 rate. Los Angeles serves very many small pick up points, primarily in the local area. All routes are accomplished by ground transportation with the trip to Las Vegas and Nellis AFB requiring an overnight stay away from home. Figure 7 shows the service area and trips away from the Los Angeles area.

TABLE IX

Los Angeles Route Summary
(in thousands)

ROUTE	MEAN	MAX	S.D.	90	95	99
					REQ. CAP.	
MONDAY DESERT	2.02		.68	3.07	3.32	3.81
TUESDAY LCL	.34		.30	.72	.83	1.04
LAS VEGAS	.94		.42	1.47	1.62	1.92
SHIP YARD	3.64		1.96	6.15	6.86	8.28
VANDENBURG	.90		.30	1.29	1.40	1.62

The major accounts served by the Los Angeles ARFCOSTA, besides the over the counter material, are the Long Beach Ship Yard and Naval Base complex, El Toro MCAS, Norton AFB, and Las Vegas.

Recommendations. ARFCOS should investigate com-

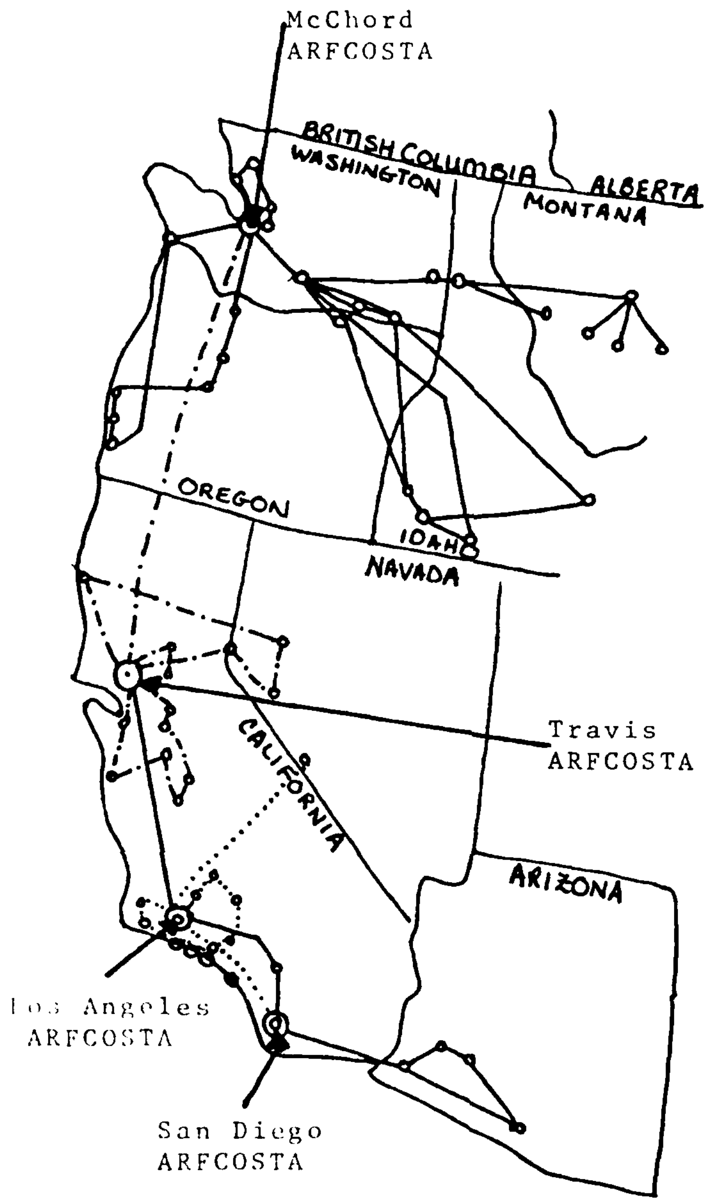

Fig 7. Los Angeles, McChord, San Diego and Travis ARFCOSTA Service Areas

bining the responsibilities of the Los Angeles station with those of San Diego. Because of the proximity to San Diego ARFCOSTA, it would be possible to serve all the Los Angeles accounts from San Diego. This could be accomplished by setting up a temporary ARFCOSTA once each week, and making all of the accounts within the greater Los Angeles area come to the consolidation point. The Las Vegas and Vandenburg routes could be served by air taxi, while El Toro and the Ship Yard would be served by truck on the way to the temporary ARFCOSTA.

McChord Results. McChord ARCCOSTA is an Air Force station commanded by a Chief Master Sergeant. It is manned by four couriers and three assistants, being employed at 0.16 and 0.21 utilization factors respectively. In addition to functioning as the gateway to Alaska, McChord serves accounts throughout Washington, Idaho, Oregon, and Montana. Figure 7 depicts the service area and routes. Table X summarizes the results of the simulation.

TABLE X

McChord Route Summary
(in thousands)

ROUTE	MEAN MAX	S.D.	90 REQ. CAP.	95 REQ. CAP.	99 REQ. CAP.
MONTANA	1.16	.45	1.74	1.90	2.22
OREGON	.23	.13	.40	.44	.54
WHIDBEY IS.	.24	.12	.40	.44	.53
IDAHO	.29	.23	.59	.67	.84
BREMERTON	.77	.31	1.17	1.28	1.51
FT LEWIS	8.50	3.47	12.91	14.16	16.65

The monthly drive to Hoquiem is not listed. It produces almost no weight and was modeled as a constant figure of two pounds. The scheduled trips to Adak and Elmendorf Alaska are modeled for time, but not weight.

Montana and Idaho are served by small airplane contract. The other routes are accomplished by ground transportation.

Recommendations. ARFCOS should analyze converting the Oregon truck trip to an air taxi trip. The Oregon run is an ideal candidate for a small airplane. It currently takes two days to complete the route; it could be accomplished in one day via air. It also has a very low expected maximum weight.

Norfolk Results. Norfolk ARFCOSTA is manned by Navy personnel and commanded by a CWO4. Seven couriers and seven assistant couriers are assigned to this station. Their utilization rates of .24 and .20 are among the highest in the system. Norfolk uses primarily ground transportation to serve their customers, but they do fly MAC, commercial, and small air taxi airplanes. Norfolk's largest account is the Communication Material Issuing Office (CMIO) at Norfolk which both supplies and demands in excess of 30,000 pounds each month. Its over-the-counter customers account for 20,000 pounds of material handled. Table XI summarizes the results of the simulation. Figure 2 depicts the routes and areas served by Norfolk.

TABLE XI

Norfolk Route Summary
(in thousands)

ROUTE	MEAN MAX	S.D.	90	95 REQ. CAP.	99
ROSEY ROADS	.55	.18	.78	.85	.98
ROUTE 6	1.05	.26	1.39	1.48	1.67
ROUTE 8	.87	.25	1.19	1.28	1.46
LANGLEY	.69	.24	.99	1.08	1.26
POPE	5.17	1.61	7.23	7.81	8.92

Recommendations. ARFCOS should analyze the southeastern stations, Norfolk, Charleston, and Jacksonville, examining alternate routes and account assignments. Cost efficiencies may be obtained by combining routes and lessening trips. The workload of the station should be closely examined; it appears that two additional people are needed to continue to provide personal service to the local accounts.

Offutt Results. Offutt ARFCOSTA is an Air Force Station manned by five couriers, five assistant couriers, and commanded by a Chief Master Sergeant. Manpower utilization rates are .25 for the couriers and .09 for the assistants. The high rate for the couriers and low rate for the assistants is due primarily to the number of commercial flights, upon which only the courier is sent. Offutt serves its customers, who cover an area including Nebraska, Kansas, Missouri, Iowa, and Minnisota, using both ground and air transportation. Figure 8 shows the area and major routes. In addition to the routes depicted in table XII, Offutt also has a daily flight to Washington, DC. Table XII summarizes

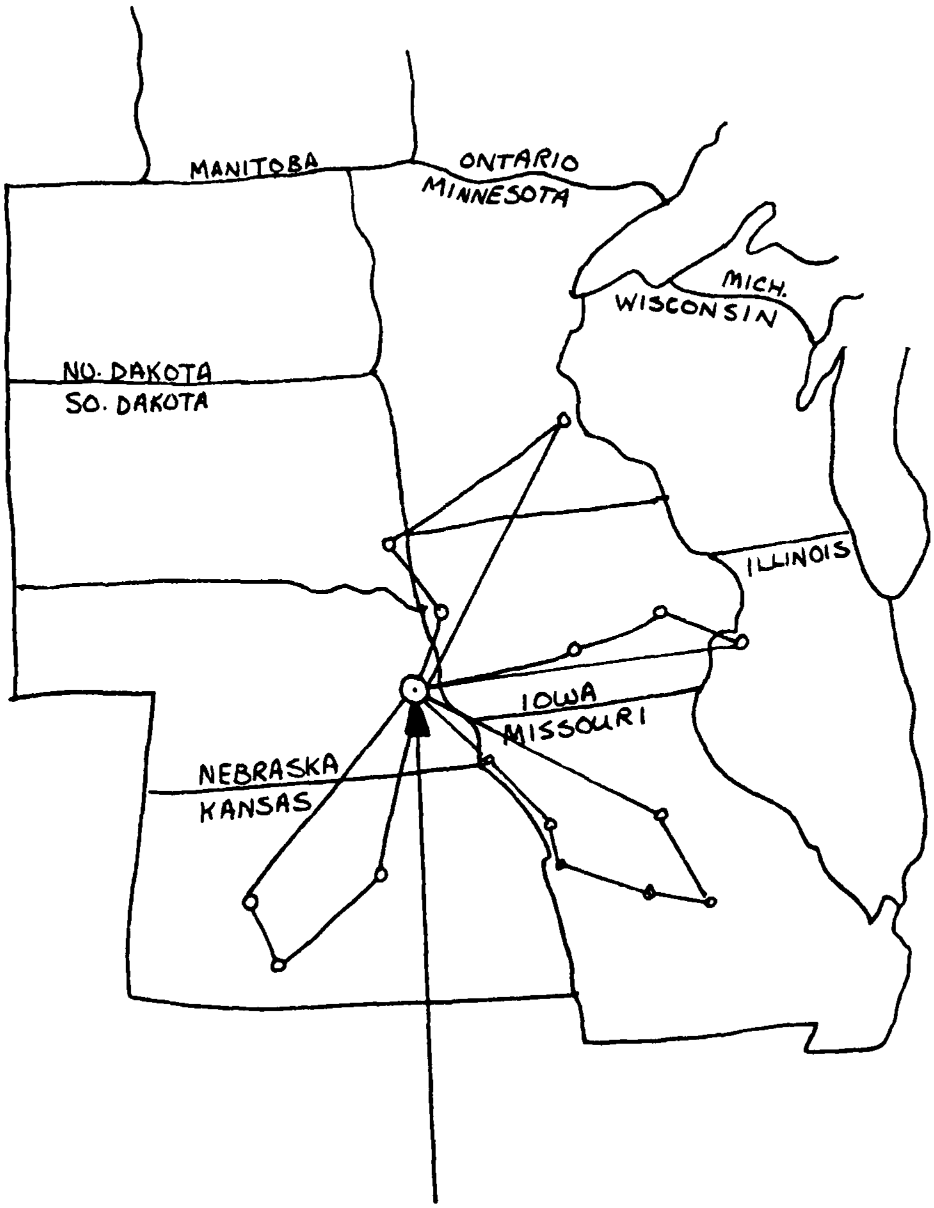

Fig 8. Offutt
ARFCOSTA Service Area

the results of the simulation.

TABLE XII

Offutt Route Summary
(in thousands)

ROUTE	MEAN MAX	S.D.	90	95 REQ. CAP.	99
KANSAS CITY	3.64	2.10	6.33	7.10	8.62
FORBES	1.04	.51	1.69	1.88	2.25
TUESDAY	.59	.17	.81	.87	1.00
CEDAR RAPIDS	.13	.09	.24	.27	.34
SIOUX FALLS	.51	.18	.74	.81	.94
ST. LOUIS	1.18	.10	1.30	1.33	1.40

Offutt's largest accounts are in Kansas City, St. Louis, and locally on Offutt.

Recommendations. Because there is nothing clearly inefficient with the Offutt route structure, the researchers have no recommendations to investigate the routes. ARFCOS should, however, investigate the workload of the couriers. A sixth courier is required to allow for annual leave, and other absences from the station.

San Diego Results. San Diego ARFCOSTA is commanded by a Navy CWO4 and manned with nine couriers, and nine assistant couriers with utilization rates of 0.11 and 0.12, respectively. Its service area, depicted in figure 7, includes primarily nearby Navy and DOD contract facilities, but also goes as far east as Arizona.

TABLE XIII

San Diego Route Summary
(in thousands)

ROUTE	MEAN MAX	S.D.	90	95	99
				REQ. CAP.	
ARIZONA	3.40	.69	4.28	4.53	5.03
CAMP PEND	2.24	1.17	3.73	4.15	4.99

San Diego's largest account, which is not depicted in Table XIII's summary, is the CMIO at San Diego which both supplies and demands over 30,000 pounds of material each month.

Recommendations. ARFCOS should model the Los Angeles and San Diego routes being served as one station at San Diego, with the Los Angeles local accounts all being required to go to the temporary ARFCOSTA, as is discussed in the Los Angeles section. Alternative routes and customer assignments could also be modeled if fine tuning, instead of major surgery, is required.

Travis Results. Travis ARFCOSTA is commanded by an Air Force Captain, and manned with 12 couriers and nine assistant couriers. Travis is co-located with the largest west coast MAC aerial port, allowing easy access to MAC airlift to the Pacific. Travis uses a combination of transportation modes including truck, air taxi, and QUICKTRANS. Its service area, as depicted in figure 7, covers northern California, but goes as far south as Lemoore NAS in the San Joaquin Valley, and as far east as Reno, NV. The largest accounts handled by Travis are the Moffett Naval Air Station accounts, delivered on the Tuesday Road route, and the numerous local accounts, handled over the counter. Travis also ships to and receives from McChord 12,000 to 15,000 pounds per month via QUICKTRANS.

TABLE XIV

Travis Route Summary
(in thousands)

ROUTE	MEAN MAX	S.D.	90	95	99
				REQ. CAP.	
TUESDAY ROAD	1.80	.25	2.12	2.22	2.40
WEDNESDAY RD	.95	.29	1.32	1.42	1.63
NORTH	.13	.19	.37	.44	.58
ODD FRIDAY	1.22	.26	1.55	1.64	1.83

Table XIV summarizes the customer serving routes operated out of Travis.

Recommendations. The researchers have no recommendations for further study on Travis ARFCOSTA.

Wright-Patterson Results. Wright-Patterson ARFCOSTA is an Air Force station commanded by an Air Force Captain, and manned by 15 couriers and assistants with a combined individual utilization of .14. The station primarily uses trucks to serve its customers, with the exception of two LOGAIR routes, one serving Loring ME and other Northeastern points, and the other serving upper Michigan and Grand Forks, ND. The remainder of the service area includes Ohio, Indiana, Illinois, Kentucky, and Wisconsin. Figure 2 depicts the service area, and major routes. The results of the simulation are summarized in Table XV.

The major customer served by Wright-Patterson is located on the base; a trip is made to the Dayton airport each day to meet the courier from the Ft. Meade station to serve this account.

TABLE XV

Wright-Patterson Route Summary
(in thousands)

ROUTE	MEAN MAX	S.D.	90 REQ. CAP.	95 REQ. CAP.	99 REQ. CAP.
ROUTE 1	.59	.09	.70	.73	.79
ROUTE 2	.72	.47	1.32	1.49	1.83
ROUTE 3	1.00	.27	1.35	1.44	1.64
ROUTE 4	1.11	.56	1.83	2.03	2.41
ROUTE 5	.29	.10	.37	.41	.48
ROUTE 6	1.79	1.55	3.77	4.34	5.46
ROUTE 7	1.73	.37	2.21	2.34	2.61

Recommendations. Further analysis of the routes should be made to determine the savings possible from a restructuring of routes, and a conversion to a small air taxi contract. Based on the mean maximums for the routes, which are currently served by truck, and, which require an overnight stay away from home (Routes 1-4), it is apparent that some routes could be easily converted to air taxi with potential savings.

Analysis of Alternatives

This section uses the model to analyzed the manpower and vehicle impact of two recommendations discussed in the previous section.

San Diego. The accounts at Phoenix and Tucson, Arizona were reassigned from San Diego to Kelly ARFCOSTA. Because Kelly already visits the cities on the LOGAIR flight, the only change necessary for Kelly was to use the appropriate distributions used for the San Diego route. Little additional time is required for the Kelly couriers to serve these accounts. The LOGAIR plane is already on the ground, and the loading and unloading is accomplished by air freight personnel assigned to the base. The change necessary for San Diego was changing the route so the couriers returned to home from Yuma, instead of continuing east. The model was run with Kelly serving the Phoenix and Tucson areas. If Kelly did serve the accounts, the weights required for the Kirtland Route would become:

mean max	4.42
s.d.	.93
90%	5.61
95%	5.95
99%	6.59

These weights are within the carrying capacity of the LOGAIR airplane. Having those four accounts served by Kelly presumes Ft. Huachuca accounts would continue to meet the ARFCOS couriers in Tucson and the Scottsdale accounts would meet the couriers at Luke AFB.

For San Diego, when the route to Arizona is shortened to driving to Yuma and returning in one day, the individual utilization rates for the San Diego couriers and assistants decreases to 0.10 and 0.11, from 0.11 and 0.12. The differences seems insignificant, but when the average utilization column is examined, a drop from 1.00 to .87 for the couriers and from 1.09 to .96 for the assistants is found. When divided by .19 to find the required manpower, the required manpower drops from six to five for the couriers and assistants. Two extra people are currently needed to serve Arizona. By having Kelly serve those customers, San Diego can save two manpower positions. It is harder to obtain manpower authorizations than operating funds, so having the ability to see how manpower can be reduced is a major benefit of the model.

Because the distribution of weights is not normally distributed, Tchebycheff's theorem is applied to determine the confidence intervals (20:289). The required vehicle capacity for the shortened Arizona trip becomes:

mean max	.492
s.d.	.42
90%	1.752
95%	2.592
99%	4.692

Wright-Patterson. Wright-Patterson's route structure is such that it can conveniently be flown by small airplanes. The accounts are all close to airports, and the required weight capacities of the routes are small. The present routes are changed to air routes by changing the time spent traveling between points. Speeds of 125 miles per hour in an easterly direction, 90 miles per hour in a westerly direction, and 110 miles per hour north/south are used to compute times (12). All routes can then be served in a single day.

When the model is run in this configuration, the average utilization of the couriers decreases from 2.09 to 1.6, and the average individual utilization drops from 0.14 to 0.11. The required manpower decreases from 11 to nine.

Wright-Patterson uses one courier to work the day prior to a route preparing the next day's material. Other stations do not; they have the people who are working in the vault prepare the next day's material. When Wright-Patterson is modeled without the day prior requirement and with serving all customers via small airplane, the average individual utilization drops to 0.10 requiring 8.15 people instead of 8.42. Consistant work standards have not been by ARFCOS Headquarters, so comparisons between stations cannot be made. This model does allow the effects of a given policy on a single station to be determined.

V. RECOMMENDATIONS FOR FURTHER RESEARCH

General Conclusions

ARFCOS is an exceptionally large system. Each station, when viewed individually, appears to be serving a necessary function, and, without a basis for comparison, appears to be using its personnel in an efficient manner. When the stations are viewed as a whole, however, the system overlap of geographical areas of responsibility, inconsistencies in manning and service policies, and lack of standards against which to measure the performance of the ARFCOSTAS, stands out. Moreover, cursory analysis indicates considerable potential for combining stations and streamlining operations.

The system has grown to meet the demands of the customers, but the needs of the customers are not constant. Because of loss of government contracts, last year's major account may not be an account next year. The sun-belt has been gaining in industrial and high technology businesses; accounts move. If one were to design the lowest cost system to meet today's needs there would be no assurance of being able to meet tomorrow's needs. The demand for ARFCOS's service has been growing at approximately 14% a year (9). Even though ARFCOS would like to provide door to door service to all accounts, the manning does not allow for it at all stations. Even less service may be provided in the future if additional manning is not authorized.

This research has collected data on approximately 365 consolidated pickup and delivery points, analyzed the underlying probability distributions of the demand at those points, analyzed the system both as it currently exists, and analyzed selected alternative changes that offered potential manpower savings. By manipulation of the models, insights into the workings of the Armed Forces Courier Service have been gained. The recommendations for further analysis presented in the sections for each ARFCOSTA are based on those insights and are not parochial. This thesis provides the Courier Service with a strategic planning tool; long range plans concerning where facilities should be located to provide cost effective service can be analyzed using the models provided. Questions concerning numbers and types of required manpower, ARFCOS's most constrained resource, can be answered through the use of the models.

Further Studies

SLAM II is a highly flexible tool. However, the process of manually computing routes is very tedious. A program which allocates demand points to ARFCOSTAS and provides automatic route structures would be able to interface with the provided models and allow exceptional "What if ..." asking capabilities. A routing algorithm would aid immeasurably in the planning process. Such a program should build files of routes which can then be read by FORTRAN subroutines added to the present model.

Accurate source-destination information would allow a different technique of modeling the system and would provide the basis for determining lower cost distribution center locations. Using such data, which was not available for this research, the ARFCOS system could be modeled using Kuehn and Hamberger's techniques (10).

Kuehn and Hamberger's simulation model approached the warehouse location problem with three principal heuristics. These heuristics could be used as the foundation of the manipulation of the ARFCOS model. The first rule of thumb states that the majority of geographical locations are inappropriate for regional warehouses; locations at or near concentrations of demand offer the most promise. Approaching the problem in this manner allows certain locations to be forced into the solution based on the decision maker's evaluation of either the political ramifications of the problem or any other criteria which he deems appropriate. The second heuristic states that a near optimum solution may be obtained by adding locations one at a time, adding each time the warehouse location which produces the greatest savings for the entire network. This rule prevents having to check all possible combinations of warehouses. Last, only a small subset of potential sites need be evaluated in detail in order to determine the next site to be added (10).

Three advantages are accrued by use of a heuristic formulation of the problem: flexibility of specifications, large scale problems can be screened, and economy of computer time (11:84). In addition, the "What if ..." questions are much more easily answered after the model has been built and implemented on a computer.

Cost Considerations

Many of the questions which arise in this thesis concern trade-offs among people, time, and service. Additional fine-tuning of the models to more accurately reflect the manpower usage is needed. Those stations which the model identified as overmanned should be examined to determine the reason(s) for such appearances.

Additionally, studies to quantify the costs involved in providing higher levels of customer service by maintaining higher manning should be made so that the ARFCOS managers can make better informed, and hence make more effective, decisions. These cost figures could be incorporated into the model so that the real dollar values of different serving policies can be compared.

Appendix A: Distributions for Consolidated Points

BOSTON ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
ALBANY.IN	BETA	.118	.119	.3315	.692
ALBANY.OUT	UNIFORM	.075	.025	0	.15
AUGUSTA.IN	GAMMA	.003	.004	.6152	.0054
AUGUSTA.OUT	CONS	0			
BANGOR.IN	GAMMA	.175	.200	.765	.2291
BANGOR.OUT	CONS	0			
BRUNSWICK.IN	GAMMA	1.407	1.23	1.3	1.083
BRUNSWICK.OUT	GAMMA	.306	.471	.4492	.3515
DOVER.IN	BETA	10.25	4.505	.3113	.3412
DOVER.OUT	NORMAL	9.574	3.424		
E GRANBY.IN	GAMMA	.038	.019	3.794	.0100
E GRANBY.OUT	CONS	.01			
FORT DRUM.IN	GAMMA	.051	.084	.3681	.139
FORT DRUM.OUT	GAMMA	.013	.035	.1343	.0943
FT DEVENS.IN	GAMMA	1.393	1.351	1.062	1.311
FT DEVENS.OUT	UNIFORM	1.812	.912	.233	3.390
HALIFAX.IN	BETA	.022	.032	.0382	.1027
HALIFAX.OUT	CONS	0			
HANSCOM.IN	GAMMA	.460	.248	3.444	.1336
HANSCOM.OUT	GAMMA	.223	.207	1.159	.1921
LAWRENCE.IN	GAMMA	.032	.071	.2015	.158
LAWRENCE.OUT	CONS	0			
LCL.IN	GAMMA	.228	.197	1.333	.1707
LCL.OUT	GAMMA	.083	.169	.2404	.3442
MANCHESTER.IN	GAMMA	.045	.063	.5057	.0883
MANCHESTER.OUT	GAMMA	.017	.039	.1919	.0908
MAYNARD.IN	BETA	.105	.143	.1489	.432
MAYNARD.OUT	8% = .75				
MAYNARD.OUT	CONS	.001			
MCGUIRE.IN	GAMMA	.1145	.294	.1517	.7553
MCGUIRE.OUT	GAMMA	.899	1.72	.2703	3.231
NASHUA.IN	GAMMA	.121	.162	.5572	.217
NASHUA.OUT	UNIFORM	.046	.025	.002	.089
NATICK.IN	GAMMA	.033	.034	.9119	.0365
NATICK.OUT	CONS	0			
NEW LONDON.IN	WEIBULL	2.45	1.107	20353	2.765
NEW LONDON.OUT	GAMMA	1.347	.620	4.715	.2857
NEWPORT.IN	BETA	.428	.41	.3023	.9929
NEWPORT.OUT	BETA	.048	.045	.1919	.3072
OTC.IN	GAMMA	.475	.489	.9451	.5028
OTC.OUT	GAMMA	.359	.539	.4423	.8076
PORTSMOUTH.IN	GAMMA	.316	.501	.3972	.7954
PORTSMOUTH.OUT	BETA	.098	.168	.1052	.4947

Account	Curve	Mean	S.D.	Alpha	Beta
PROVIDENCE.IN	CONS	0			
PROVIDENCE.OUT	GAMMA	.370	.169	4.813	.0769
S PORTLAND.IN	GAMMA	.329	.623	.2781	1.1811
S PORTLAND.OUT	UNIFORM	.225	.110	.0	.45
SYRACUSE.IN	BETA	.192	.258	.1382	.6737
SYRACUSE.OUT	BETA	.043	.083	.0643	.4027
WELLESLEY.IN	GAMMA	.415	.564	.5421	.7662
WELLESLEY.OUT	GAMMA	.38	.445	.7292	.5217
WESTFIELD.IN	GAMMA	.024	.023	1.104	.0215
WESTFIELD.OUT	UNIFORM	.015	.005	.0	.03
WESTOVER.IN	GAMMA	.050	.039	1.633	.0307
WESTOVER.OUT	CONS	0			
WINTERHARBOR.IN	BETA	.324	.171	.3356	.4325
WINTERHARBOR.OUT	BETA	.275	.221	.4234	1.079
WORCHESTER.IN	BETA	.036	.019	.9091	.6602
WORCHESTER.OUT	CONS	0			

CHARLESTON ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
ANNISTON.IN	WEIBULL	.107	.064	1.729	.12
ANNISTON.OUT	50%=0	50%=UNIFORM			
ATLANTA.IN	BETA	.47	.344	.2833	.2812
ATLANTA.OUT	BETA	.195	.147	.34	.4235
AUGUSTA.IN	GAMMA	.942	.855	1.214	.7759
AUGUSTA.OUT	GAMMA	.336	.424	.6266	.5354
BEAUFORT.IN	WEIBULL	.26	.152	1.767	.2917
BEAUFORT.OUT	25%=.002	8%=.025	68%=0		
BIRMINGHAM.IN	WEIBULL	.117	.138	.8454	.1066
BIRMINGHAM.OUT	UNIFORM				
BLYTHEVILLE.IN	WEIBULL	.316	.167	1.979	.357
BLYTHEVILLE.OUT	WEIBULL	.026	.035	.7559	.0222
COLUMBUSAFB.IN	92%=.03	8%=.412			
COLUMBUSAFB.OUT	33%=.002	67%=0			
DOBBINS.IN	GAMMA	.59	.403	2.144	.2754
DOBBINS.OUT	GAMMA			.7437	.3247
FT BENNING.IN	WEIBULL	.595	.853	.733	.49
FT BENNING.OUT	8%=2.129	92%=ABOVE			
FT BENNING.OUT	GAMMA	.033	.031	1.117	.0294
FT GORDON.IN	UNIFORM	(1.3, 2.3)			
FT GORDON.OUT	UNIFORM	(.1, .6)			
FT STEWART.IN	BETA	2.171	1.872	.3763	.8215
FT STEWART.OUT	8%=5.023	92%=ABOVE			
FT STEWART.OUT	WEIBULL	.22	.417	.5658	.1347
GREER.IN	WEIBULL	.027	.035	.7754	.0229
GREER.OUT	0				
JACKSON,MS.IN	GAMMA	.065	.049	1.744	.0371
JACKSON,MS.OUT	0				
JACKSON,TEN.IN	64%=.005	36%=.482			
JACKSON,TEN.OUT	0				
LCCOTC.IN	WEIBULL	3.677	3.448	.067	3.771
LCCOTC.OUT	TRIAG	(.519, 3.307, 4.461)			
MEMPHIS.IN	BETA	.089	.058	.5063	.8266
MEMPHIS.OUT	8%=.11	42%=.005	50%=0		
MERIDIAN.IN	GAMMA	.054	.025	4.836	.0113
MERIDIAN.OUT	50%=0	50%=.033			
MONTGOMERY.IN	WEIBULL	.218	.079	3.018	.244
MONTGOMERY.OUT	8%=.735				
MONTGOMERY.OUT	WEIBULL	.04	.052	.7785	0.0344
MYRTLEBEACH.IN	GAMMA	.262	.162	2.629	.0999
MYRTLEBEACH.OUT	UNIFORM	(.01, .06)			
NAVY BASE.IN	TRIAG	(1.4, 2, 8)			
NAVY BASE.OUT	UNIFORM	(.2, 5.5)			
ROBINS.IN	8%=14.86	92%=ABOVE			
ROBINS.IN	GAMMA	1.603	1.032	2.414	.6639
ROBINS.OUT	16%=1.646	84%=ABOVE			
ROBINS.OUT	WEIBULL	102	.118	.8644	.0943

Account	Curve	Mean	S.D.	Alpha	Beta
SHAW.IN	GAMMA	1.243	.569	4.781	.26
SHAW.OUT	WEIBULL	.311	.325	.9577	.3049
TULLAHOMA.IN	WEIBULL	.312	.347	.9003	.2968
TULLAHOMA.OUT	BETA	.04	.052	.1192	.3037

DENVER ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
BUCKLEY.IN	GAMMA	.704	.414	2.887	.2438
BUCKLEY.OUT	GAMMA	4.106	.917	20.04	.2048
CHEYENNE.IN	GAMMA	.463	.272	2.904	.1595
CHEYENNE.OUT	WEIBULL	.135	.127	1.067	.1384
COLO SPGS.IN	GAMMA	.649	.372	3.035	.2127
COLO SPGS.OUT	GAMMA	16.91	14.63	1.335	12.66
DENVER.IN	GAMMA	.116	.116	.9908	.1173
DENVER.OUT	WEIBULL	.158	.181	.8437	.1446
DENVOTC.IN	WEIBULL	.257	.325	.7976	.2263
DENVOTC.OUT	GAMMA	.079	.156	.26	.3051
F E WARREN.IN	BETA	.460	.401	.2744	.3984
F E WARREN.OUT	GAMMA	.019	.027	.516	.0368
FT CARSON.IN	WEIBULL	2.044	1.687	1.218	2.181
FT CARSON.OUT	WEIBULL	.094	.14	.6859	.0726
LOWERY.IN	WEIBULL	.219	.2564	.8573	.2024
LOWERY.OUT	GAMMA	.098	.138	.5023	.1949
MINOT.IN	GAMMA	1.378	.868	2.52	.547
MINOT.OUT	WEIBULL	.033	.065	.5478	.0191
PETE FIELD.IN	8% = 2.2				
PETE FIELD.IN	GAMMA	.172	.077	5.078	.0339
PETE FIELD.OUT	WEIBULL	.106	.27	.4569	.0442
RAPID CITY.IN	WEIBULL	1.452	.755	2.013	1.638
RAPID CITY.OUT	GAMMA	.049	.062	.6328	.0774
SALT LAKE.IN	BETA	.854	.518	.2751	.957
SALT LAKE.OUT	WEIBULL	.246	.383	.6625	.1838
WINNEPEG.IN	GAMMA	.099	.062	2.54	.0388
WINNEPEG.OUT	TRIAG	.02	.02	(0,.01,.125)	

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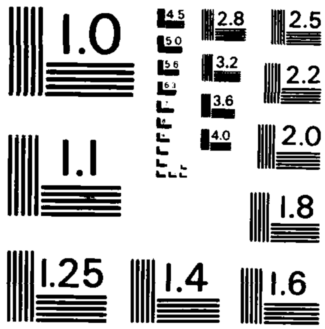

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS - 1963 - A

DOVER ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
ATL CITY.OUT	GAMMA	.009	.0113	.593	.0146
ATL CITY.IN	WEIBULL	.073	.122	.6269	.0514
BROOME.IN	GAMMA	.103	.155	.4409	.2328
BROOME.OUT	CONS	.0			
BUFFALO.IN	BETA	.143	.142	.4113	.9489
BUFFALO.OUT	CONS	.001			
CARLISLE.IN	GAMMA	.156	.059	7.002	.0223
CARLISLE.OUT	WEIBULL	.093	.284	.4077	.0295
FARMINGDALE.IN	UNIFORM	.85	.25	.4	1.3
FARMINGDALE.OUT	UNIFORM	.35	.1	.0	.7
HAGGARSTOWN.IN	BETA	.093	.063	.4848	.6636
HAGGARSTOWN.OUT	BETA	.332	.214	.3414	.5955
HARRISBURG.IN	GAMMA	.112	.089	1.601	.0702
HARRISBURG.OUT	CONS	.01			
INDIANTOWN.IN	WEIBULL	.031	.02	1.598	.0344
INDIANTOWN.OUT	CONS	.001			
LOCAL.IN	GAMMA	.1587	.1118	2.013	.0788
LOCAL.OUT	NOT AVAILABLE				
MORGANTOWN.IN	BETA	.029	.019	.5133	.583
MORGANTOWN.OUT	CONS	.001			
MT POCONO.IN	GAMMA	.820	.755	1.182	.694
MT POCONO.OUT	GAMMA			1.182	.694
NEW HAVEN.IN	WEIBULL	.084	.056	1.526	.0932
NEW HAVEN.OUT	CONS	.0			
NEWBURGH.IN	GAMMA	.055	.072	.5785	.0951
NEWBURGH.OUT	CONS	.0			
ROCHESTER.IN	GAMMA	.011	.011	1.057	.0104
ROCHESTER.OUT	UNIFORM	.3	.1	.0	.6
SUFFOLK.IN	WEIBULL	.052	.084	.6387	.037
SUFFOLK.OUT	CONS	.001			
SUFFOLK.OUT	8% = .3				
WHITE PLNS.IN	WEIBULL	.042	.072	.6177	.0292
WHITE PLNS.OUT	CONS	.0			
WILMINGTON.IN	GAMMA	.041	.022	3.332	.0122
WILMINGTON.OUT	CONS	0			

JACKSONVILLE ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
ALBANY GA.OUT	25% = .1				
ALBANY GA.IN	TRIAG	.112	.035	(.02,.112,.2)	
ALBANY GA.OUT	CONSTANT	.001			
BAY ST LOUIS.IN	UNIFORM	.129	.07	.005	.25
BAY ST LOUIS.OU	BETA	.087	.068	.2347	.2046
CAPE KENN.IN	CONSTANT	.15			
CAPE KENN.OUT	CONSTANT	31.0			
EGLIN.IN	TRIAG	.8	.4	(.2,.69,1.8)	
EGLIN.OUT	BETA	.265	.3	.3275	.8255
FT LAUDERDALE.IN	CONSTANT	.8			
FT LAUDERDALE.OU	CONSTANT	5.0			
FT RUCKER.IN	GAMMA	.077	.034	5.268	.0146
FT RUCKER.OUT	8% = .11				
FT RUCKER.OUT	UNIFORM	.007	.003	.000	.015
GAINSVILLE.IN	UNIFORM	.003	.002	.000	.006
GAINSVILLE.OUT	CONSTANT	0			
HATTIESBURG.IN	CONSTANT	.001			
HATTIESBURG.OUT	CONSTANT	0			
HOMESTEAD.IN	GAMMA	1.485	.58	6.562	.2263
HOMESTEAD.OUT	GAMMA	.6147	.366	2.823	.2178
HONEYWELL.IN	GAMMA	.121	.1141	1.116	.108
HONEYWELL.OUT	TRIAG	14.42	5.217	(5.5 8.7 29)	
KEESLER.IN	UNIFORM	.368	.137	.13	.606
KEESLER.OUT	WEIBL	.144	.139	1.03	.1453
KEY WEST.IN	GAMMA	.558	.378	2.179	.2559
KEY WEST.OUT	UNIFORM	.245	.077	.100	.400
LOCAL & OTC.IN	GAMMA	3.507	1.859	3.558	.9858
LOCAL & OTC.OUT	BETA	1.795	.517	.7759	1.06
MAYPORT.IN	UNIFORM	1.7	.5	.9	2.5
MAYPORT.OUT	UNIFORM	.375	.2	.0	.75
MCDILL.IN	GAMMA	2.247	.975	5.31	.4232
MCDILL.OUT	GAMMA	1.094	.692	2.502	.4373
MOODY.IN	TRIAG	.1	.05	(.04,.09,.226)	
MOODY.OUT	CONSTANT	.001			
NEW ORLEANS.IN	UNIFORM	.37	.12	.15	.6
NEW ORLEANS.OUT	TRIAG	.12	.088	(0,.02,.2)	
ORLANDO.IN	GAMMA	.06	.0198	.6494	.2461
ORLANDO.OUT	CONSTANT	.01			
PATRICK.IN	UNIFORM	2.1	.7	.95	2.9
PATRICK.OUT	GAMMA	1.04	.916	1.278	.8099
PENNSACOLA.IN	GAMMA	1.358	.88	2.382	.5701
PENNSACOLA.OUT	GAMMA	1.113	.829	1.805	.6168
ST SIMONS.IN	UNIFORM	.015	.007	.000	.030
ST SIMONS.OUT	8% = .05				
ST SIMONS.OUT	CONSTANT	0			
TALLAHASSEE.IN	CONSTANT	0			
TALLAHASSEE.OUT	CONSTANT	0			

Account	Curve	Mean	S.D.	Alpha	Beta
THOMASVILLE.IN	GAMMA	.116	.156	.5577	.2087
THOMASVILLE.OUT	8% = .04				
THOMASVILLE.OUT	CONSTANT	0			
TYNDALL.IN	GAMMA	.219	.116	3.575	.0613
TYNDALL.OUT	8% = .125				
TYNDALL.OUT	UNIFORM	.015	.007	.000	.030

KELLY ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
ALTUS.IN	GAMMA	.366	.155	5.617	.0652
ALTUS.OUT	GAMMA	.017	.014	1.421	.0118
AMARILLO.IN	WEIBULL	.036	.53	.7035	.0286
AMARILLO.OUT	8% = .075				
AMARILLO.OUT	CONS	.001			
AUSTIN.IN	80% = 0	20% = 2.265			
AUSTIN.OUT	CONS	.0			
BARKSDALE.IN	UNIFORM	1.045	.331		
BARKSDALE.OUT	8% = 1.061				
BARKSDALE.OUT	BETA	.068	.062	.2328	.3736
BERGSTROM.IN	WEIBULL	.853	.509	1.725	.9562
BERGSTROM.OUT	BETA	.239	.156	.6081	.8129
CANNON.IN	GAMMA	.326	.204	2.549	.1279
CANNON.OUT	WEIBULL	.171	.227	.7649	.1463
CARSWELL.IN	BETA	1.109	.4752	.4038	.5475
CARSWELL.OUT	WEIBULL	.275	.249	1.107	.2859
CHASE FIELD.IN	WEIBULL	.004	.003	1.43	.0043
CHASE FIELD.OUT	CONS	.001			
CORPUS.IN	WEIBULL	.013	.010	1.34	.014
CORPUS.OUT	UNIFORM	.001	.001	.0	.005
DALLAS.IN	BETA	1.109	.475	.4038	.5475
DALLAS.OUT	GAMMA	.459	.398	1.324	.3466
DENVER.IN	GAMMA	4.176	2.157	3.749	1.114
DENVER.OUT	GAMMA	8.31	5.492	2.29	3.629
DYESS.IN	BETA	.59	.236	.8986	.5144
DYESS.OUT	WEIBULL	.055	.074	.7582	.0468
ELLINGTON.IN	GAMMA	.321	.359	.8007	.4004
ELLINGTON.OUT	WEIBULL	.024	.027	.9071	.023
ENGLAND.OUT	8% = 1.36				
ENGLAND.IN	GAMMA	2.224	1.869	1.416	1.571
ENGLAND.OUT	WEIBULL	.04	.056	.7246	.0326
FT HOOD.IN	GAMMA	2.199	1.281	2.948	.7458
FT HOOD.OUT	GAMMA	.942	.871	1.17	.8056
FT POLK.IN	BETA	.285	.24	.2168	.3378
FT POLK.OUT	16% = UNFRM (.3 ,.5)				
FT POLK.OUT	UNIFORM	.015	.005	.0	.03
FT SILL.IN	GAMMA	.204	.141	2.088	.0974
FT SILL.OUT	WEIBULL	.142	.086	1.707	.1594
FT SMITH.IN	GAMMA	.036	.014	6.414	.0056
FT SMITH.OUT	CONS	.0			
GOODFELLOW.IN	BETA	1.989	.597	1.399	3.215
GOODFELLOW.OUT	GAMMA	1.31	.626	4.369	.2995
HOLLOMAN.IN	GAMMA	1.481	.669	4.904	.3021
HOLLOMAN.OUT	WEIBULL	.887	.766	1.162	.9351
HOT SPRINGS.IN	GAMMA	.037	.036	1.093	.034
HOT SPRINGS.OUT	8% = .1				
HOT SPRINGS.OUT	CONS	.001			

Account	Curve	Mean	S.D.	Alpha	Beta
KELLYLCL.IN	BETA	55.08	40.48	.0995	.096
KELLYLCL.OUT	BETA	58.77	35.75	.2031	.156
KINGSVILLE.IN	GAMMA	.014	.016	.7713	.0179
KINGSVILLE.OUT	16% = UNFRM(0,.05)				
KINGSVILLE.OUT	CONS	0			
KIRTLAND.IN	GAMMA	1.021	.457	4.988	.2046
KIRTLAND.OUT	BETA	.465	.336	.4998	.5905
LAREDO.IN	67% = 0	33% = .003			
LAREDO.IN	UNIFORM	.002	.001	.0	.005
LAREDO.OUT	CONS	.0			
LAUGHLIN.IN	GAMMA	.016	.006	8.27	.002
LAUGHLIN.OUT	CONS	0			
LITTLE ROCK.IN	GAMMA	.602	.254	5.616	.1071
LITTLE ROCK.OUT	GAMMA	.129	.184	.4911	.2623
REESE.IN	GAMMA	.018	.008	5.638	.0032
REESE.OUT	UNIFORM	.01	.003	.0	.02
SHEPPARD.IN	GAMMA	.033	.016	4.238	.0079
SHEPPARD.OUT	8% = .05				
SHEPPARD.OUT	CONS	.001			
TINKER.IN	WEIBULL	3.145	3.065	1.027	3.179
TINKER.OUT	WEIBULL	.8743	1.374	.6579	.6485
TRAVIS.IN	GAMMA	29.47	6.157	22.9	1.287
TRAVIS.OUT	WEIBULL	13.53	6.413	2.23	15.28
WASH.IN	WEIBULL	52.98	17.77	3.408	58.97
WASH.OUT	BETA	48.88	34.77	.1209	.1204
WRT-PAT.IN	GAMMA	13.22	8.626	2.348	5.63
WRT-PAT.OUT	WEIBULL	8.19	6.071	1.365	8.948

LOS ANGELES ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
ANAHEIM.IN	WEIBULL	.082	.103	.8024	.0722
ANAHEIM.OUT	WEIBULL	.061	.108	.6006	.0407
AZUSA.IN	UNIFORM	.02	.01	.005	.040
AZUSA.OUT	UNIFORM	.005	.002	.0	.02
BARSTOW.IN	CONS	0			
BARSTOW.OUT	CONS	0			
BELL.IN	UNIFORM	.02	.005	.0	.040
BELL.OUT	CONS	0			
BURBANK.IN	16% = .5				
BURBANK.IN	GAMMA	.021	.015	1.909	.0109
BURBANK.OUT	16% = UNFRM (.1,.3)				
BURBANK.OUT	CONS	0			
CAMARILLO.IN	CONS	0			
CAMARILLO.OUT	CONS	0			
CERRITAS.IN	CONS	0			
CERRITAS.OUT	CONS	0			
CORONA.IN	CONS	0			
CORONA.OUT	CONS	0			
COSTA MESA.IN	WEIBULL	.0181	.014	1.348	.0197
COSTA MESA.OUT	8% = .1				
COSTA MESA.OUT	CONS	.001			
DOWNEY.IN	25% = .26				
DOWNEY.IN	WEIBULL	.0227	.024	.9502	.0222
DOWNEY.OUT	UNIFORM	.003	.001	.0	.005
EDWARDS.IN	8% = 1.6				
EDWARDS.IN	GAMMA	.269	.145	3.431	.0785
EDWARDS.OUT	8% = 1.0				
EDWARDS.OUT	GAMMA	.062	.075	.6748	.0913
EL MONTE.IN	25% = UNFRM(.07,.15)				
EL MONTE.IN	UNIFORM	.015	.005	.0	.030
EL MONTE.OUT	CONS	.001			
EL TORO.IN	GAMMA	1.79	1.38	1.68	1.066
EL TORO.OUT	33% = .25				
EL TORO.OUT	WEIBULL	.014	.018	.7612	.0118
ENCINO.IN	WEIBULL	.015	0.007	2.185	.0172
ENCINO.OUT	UNIFORM	.008	.003	.0	.012
GEORGE.IN	GAMMA	.54	.434	1.553	.348
GEORGE.OUT	WEIBULL	.101	.22	.5086	.052
GLENDALE.IN	UNIFORM	.025	.015	.0	.05
GLENDALE.OUT	CONS	0			
GOLETA.IN	8% = .42				
GOLETA.IN	CONS	0			
GOLETA.OUT	8% = .05				
GOLETA.OUT	CONS	.001			
HUNTINGTON.IN	WEIBULL	.101	.086	1.18	.1064
HUNTINGTON.OUT	UNK				
IRVINE.IN	CONS	0			

Account	Curve	Mean	S.D.	Alpha	Beta
IRVINE.OUT	CONS	Ø			
LAOTC.IN	GAMMA	3.48	1.34	6.74	.5164
LAOTC.OUT	WEIBULL	2.8Ø7	1.35	2.199	3.17
LASVEGAS.IN	GAMMA	1.464	.9837	2.215	.661
LASVEGAS.OUT	WEIBULL	.383	.331	1.158	.4Ø27
LNG NAV SHP.IN	WEIBULL	2.3Ø6	3.7Ø8	.6456	1.675
LNG NAV SHP.OUT	35% = 1.5				
LNG NAV SHP.OUT	UNIFORM	.Ø3	Ø.Ø1	.Ø	.4
LNGBEACH.IN	16% = 3.3				
LNGBEACH.IN	UNIFORM	.Ø4	.Ø2	.Ø	.1
LNGBEACH.OUT	8% = .24				
LNGBEACH.OUT	UNIFORM	.Ø2	.Ø1	.Ø	.45
LONG NAV STA.IN	WEIBULL	1.211	1.144	1.Ø59	1.238
LONG NAVSTA.OUT	UNIFORM	.Ø4	.Ø2	.Ø	.8
LOS ANGELES.IN	8% = .45				
LOS ANGELES.IN	WEIBULL	.Ø38	.Ø48	.792	.Ø329
LOS ANGELES.OUT	8% = .22				
LOS ANGELES.OUT	UNIFORM	.Ø25	.Ø15	.Ø	.Ø5
MARCH.IN	WEIBULL	.94Ø	.468	2.111	1.Ø62
MARCH.OUT	WEIBULL	.Ø94	.1639	.6Ø4	.Ø63
NEWBURY PARK.IN	WEIBULL	.Ø12	.Ø17	.7416	.Ø1Ø3
NEWBURY PARK.OUT	CONS	Ø			
NEWPORT BCH.IN	UNIFORM	.Ø2	.Ø1	.Ø	.Ø4
NEWPORT BCH.OUT	UNIFORM	.Ø15	.ØØ5	.Ø	.Ø3
NORTON.IN	GAMMA	1.53	.892	2.948	.5196
NORTON.OUT	WEIBULL	.652	.892	.4218	.2255
ONTARIO.IN	WEIBULL	.Ø2	.Ø2	1.ØØ9	.Ø199
ONTARIO.OUT	8% = .13				
ONTARIO.OUT	CONS	Ø			
PALMDALE.IN	UNK				
PALMDALE.OUT	UNK				
PAMONA.IN	UNIFORM	.ØØ4	.ØØ2	.Ø	.ØØ8
PAMONA.OUT	CONS	.ØØ1			
PASADENA.IN	8% = .22				
PASADENA.IN	WEIBULL	.Ø14	.ØØ9	1.578	.Ø15
PASADENA.OUT	UNIFORM	.Ø2	.Ø1	.Ø	.Ø4
PT MAGU.OUT	WEIBULL	.173	.213	.8172	.1546
PT MAGU.IN	WEIBULL	.54	.38Ø	1.441	.5949
SAN DIEGO.IN	WEIBULL	6.629	3.245	2.151	7.486
SAN DIEGO.OUT	GAMMA	16.47	5.524	8.889	1.853
SANTA ANA.IN	WEIBULL	.Ø77	.113	.694	.Ø6Ø1
SANTA ANA.OUT	GAMMA	1.9	1.93	.9657	1.966
SANTA BARBRA.IN	UNIFORM	.Ø1	.ØØ3	Ø.	.Ø2
SANTA BARBRA.OUT	CONS	.ØØ3			
SEAL BEACH.IN	BETA	.116	.1411	.1276	.2694
SEAL BEACH.OUT	UNIFORM	.Ø35	.Ø2	.Ø	.6
VAN NEYES.IN	8% = 2.8				
VAN NEYES.IN	GAMMA	.142	.1Ø7	1.76	.Ø8Ø8
VAN NEYES.OUT	16% = UNFORM (.Ø6,.1)				
VAN NEYES.OUT	CONS	Ø			

Account	Curve	Mean	S.D.	Alpha	Beta
VANDENBURG.IN	WEIBULL	.607	.459	1.336	.6606
VANDENBURG.OUT	WEIBULL	.087	.21	.4727	.0389
WESTLAKE.IN	WEIBULL	.155	.227	.7005	.1228
WESTLAKE.OUT	CONS	.002			
WESTWOOD.IN	CONS	.001			
WESTWOOD.OUT	CONS	0			
WOODLAND.IN	CONS	.001			
WOODLAND.OUT	CONS	.001			

MCCHORD ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
ASTORIA.IN	UNIFORM	.015	.005	.01	.02
ASTORIA.OUT	CONS	0			
AUBURN.IN	CONS	.002			
AUBURN.OUT	CONS	0			
BANGOR.IN	GAMMA	.501	.327	2.635	.2015
BANGOR.OUT	GAMMA	.656	.607	1.169	.5607
BELLINGHAM.IN	CONS	0			
BELLINGHAM.OUT	8% = .1				
BELLINGHAM.OUT	CONS	0			
BILLINGS.IN	16% = .116				
BILLINGS.IN	UNIFORM	.005	.002	.0	.010
BILLINGS.OUT	CONS	0			
BOISE.IN	GAMMA	.052	.056	.8664	.0599
BOISE.OUT	8% = .115				
BOISE.OUT	UNIFORM	.005	.002	.0	.010
BOTHELL.IN	GAMMA	.104	.125	.6839	.1513
BOTHELL.OUT	UNIFORM	.15	.05	.0	.3
BOZEMAN.IN	16% = .45				
BOZEMAN.IN	CONS	.005			
BOZEMAN.OUT	CONS	0			
BREMERTON.IN	GAMMA	1.58	1.426	1.228	1.287
BREMERTON.OUT	GAMMA	.321	.534	.361	.8892
BUTTE.IN	50% = UNFORM(0,.1)				
BUTTE.IN	CONS	0			
BUTTE.OUT	CONS	.001			
CALDWELL.IN	CONS	0			
CALDWELL.OUT	CONS	0			
CHARLESTONOR.OUT	CONS	0			
CHARLESTONOR.IN	CONS	.002			
CHENEY.IN	GAMMA	.021	.007	9.223	.0023
CHENEY.OUT	CONS	0			
CLACKAMAS.IN	CONS	0			
CLACKAMAS.OUT	CONS	0			
COMOX.IN	UNIFORM	.003	.001	.0	.01
COMOX.OUT	8% = .1				
COMOX.OUT	UNIFORM	.004	.002	.0	.08
CP MURRAY.IN	16% = .4				
CP MURRAY.IN	UNIFORM	.06	.02	.02	.1
CP MURRAY.OUT	CONS	0			
EVERETT.IN	8% = .34				
EVERETT.IN	CONS	0			
EVERETT.OUT	CONS	0			
FAIRCHILD.IN	TRIAG	.53	.3	(.175,.513,1.122)	
FAIRCHILD.OUT	50% = 0				
FAIRCHILD.OUT	GAMMA			.5875	.0632
FT LEWIS.IN	GAMMA	4.024	3.974	1.025	3.924
FT LEWIS.OUT	GAMMA	.804	1.947	.1704	4.717
GREAT FALLS.IN	GAMMA	.039	.023	2.782	.014

Account	Curve	Mean	S.D.	Alpha	Beta
GREAT FALLS.OUT	UNIFORM	.ØØ3	.ØØ1	.Ø	.ØØ5
HARMISTON.IN	UNIFORM	.ØØ1	.ØØ1	.Ø	.ØØ3
HARMISTON.OUT	CONOS	Ø			
HELENA.IN	WEIBULL	.Ø14	.Ø26	.5664	.ØØ85
HELENA.OUT	CONS	Ø			
IDAHO FALLS.IN	GAMMA	.Ø6	.1Ø2	.344	.1742
IDAHO FALLS.OUT	8% = .ØØ5				
IDAHO FALLS.OUT	CONS	Ø			
KALLISPELL.IN	UNIFORM	.ØØ2	.ØØ1	.Ø	.ØØ5
KALLISPELL.OUT	CONS	Ø			
KENT.IN	WEIBULL	.Ø32	.Ø36	.8894	.Ø3Ø5
KENT.OUT	TRIAG	.ØØ5	.ØØ5	(Ø,.ØØØ1,.Ø5)	
KEYPORT.IN	CONS	.ØØ3			
KEYPORT.OUT	CONS	Ø			
KLAMATH FALLS.IN	UNIFORM	.15	.ØØ5	.Ø	.3
KLAMATH.OUT	CONS	Ø			
LEWISTON.IN	CONS	Ø			
LEWISTON.OUT	CONS	Ø			
MALMSTROM.IN	GAMMA	.884	.748	1.396	.6331
MALMSTROM.OUT	GAMMA	.Ø25	.Ø31	.449	.Ø551
MT HOME.IN	TRIAG	.31	.136	(.Ø5,.1952,.684)	
MT HOME.OUT	1Ø%= .1				
MT HOME.OUT	UNIFORM	.ØØ5	.ØØ2	.Ø	.Ø1Ø
NORTH BEND.IN	WEIBULL	.Ø6Ø	.117	.5554	.Ø36
NORTH BEND.OUT	8% = .115				
NORTH BEND.OUT	CONS	Ø			
OTC.IN	GAMMA	1.269	.676	3.529	.3596
OTC.OUT	WEIBULL	.786	.938	.8428	.7189
PACIFIC BEND.IN	UNIFORM	.ØØ3	.ØØ1	.Ø	.ØØ5
PACIFIC BEND.OUT	CONS	Ø			
PASCO.IN	CONS	Ø			
PASCO.OUT	CONS	Ø			
POCATELLO.IN	33% = UNIFORM(Ø,.ØØ5)				
POCATELLO.IN	CONS	Ø			
POCATELLO.OUT	CONS	Ø			
PORT ANGELES.IN	8% = .12				
PORT ANGELES.IN	UNIFORM	.Ø15	.ØØ5	.Ø	.Ø3
PORT ANGELES.OUT	CONS	Ø			
PORTLAND.IN	GAMMA	.195	.155	1.581	.1235
PORTLAND.OUT	UNIFORM	.Ø2	.ØØ8	.Ø	.Ø5
RICHLAND.IN	GAMMA	.Ø84	.138	.3689	.2267
RICHLAND.OUT	UNIFORM	.ØØ3	.ØØ2	.Ø	.Ø1Ø
SALEM.IN	8% = .Ø6				
SALEM.IN	UNIFORM	.Ø15	.ØØ5	.Ø	.Ø3
SALEM.OUT	CONS	Ø			
SEATTLE.IN	BETA	.584	.231	.4482	.4365
SEATTLE.OUT	GAMMA	.236	.231	1.Ø47	.2255
SPOKANE.IN	GAMMA	.Ø4	.Ø4	.9174	.Ø428
SPOKANE.OUT	33% = UNIFORM (.1,.15)				
SPOKANE.OUT	CONS	.ØØ2			

Account	Curve	Mean	S.D.	Alpha	Beta
TWIN FALLS.IN	UNIFORM	.01	.003	.0	.02
TWIN FALLS.OUT	CONS	0			
VANCOUVER.IN	8% = .065				
VANCOUVER.IN	CONS	0			
VANCOUVER.OUT	CONS	0			
WHIDBEY.IN	GAMMA	.2905	.224	1.685	.1724
WHIDBEY.OUT	8% = .9				
WHIDBEY.OUT	UNIFORM	.066	.032	.0	.125
YAKIMA.IN	TRIAG			(.15,.3275,.894)	
YAKIMA.OUT	GAMMA	.378	.225	2.832	.1335

MCGUIRE ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
ARGENTIA.IN	UNIFORM	(.01, .05)			
ARGENTIA.OUT	CONS	.0			
BAYONNE.IN	WEIBULL	.302	.858	.425	.1064
BAYONNE.OUT	GAMMA	.012	.024	.235	.0489
BROOKLYN.IN	GAMMA	.305	.378	.6525	.468
BROOKLYN.OUT	GAMMA	.013	.016	.6159	.0203
CAMDEN.IN	UNIFORM	.728	.42	.088	1.416
CAMDEN.OUT	UNIFORM	13.27	7.519	.335	23.12
DOVER NJ.IN	GAMMA	.068	.084	.6474	.0146
DOVER NJ.OUT	WEIBULL	.012	.023	.5456	.007
DOWNINGTON.IN	CONS	.0			
DOWNINGTON.OUT	BETA	6.844	1.708	.4082	.5666
EARLE.IN	GAMMA	.069	.058	1.394	.0492
EARLE.OUT	CONS	.0			
FORTDIX.IN	8% = .26				
FORTDIX.IN	UNIFORM	.015	.005	.0	.03
FORTDIX.OUT	GAMMA	.018	.03	.3441	.0526
FT MONMOUTH.IN	GAMMA	.640	.446	2.053	.3106
FT MONMOUTH.OUT	BETA	.272	.368	.1185	.3097
GOOSEBAY.IN	GAMMA	.015	.013	1.351	.0139
GOOSEBAY.OUT	CONS	.0			
GOVSISLAND.IN	GAMMA	.19	.171	1.237	.1537
GOVSISLAND.OUT	GAMMA	.005	.005	1.202	.0042
MCGUIRE.IN	BETA	.33	.098	1.039	.9926
MCGUIRE.OUT	GAMMA	.05	.043	1.331	.0372
NAVSHIPYARD.IN	GAMMA	1.7	1.566	1.179	1.442
NAVSHIPYARD.OUT	GAMMA	.439	.499	.7587	.5731
NEWARK.IN	WEIBULL	.012	.828	.4691	.0051
NEWARK.OUT	UNFRM	(0, .01)			
NUTLEY.IN	GAMMA	.187	.27	.477	.3907
NUTLEY.OUT	GAMMA	.949	.902	1.106	.8576
NYC.IN	GAMMA	.292	.36	.691	.4208
NYC.OUT	GAMMA	.063	.087	.5343	.1185
PHILADELPHIA.IN	GAMMA	.52	.764	.4646	1.12
PHILADELPHIA.OUT	GAMMA	.211	.362	.3401	.6213
PLAINFIELD.IN	GAMMA	.017	.021	.6368	.0259
PLAINFIELD.OUT	CONS	.0			
PRINCETON.IN	GAMMA	.114	.086	1.735	.0654
PRINCETON.OUT	GAMMA	.219	.155	1.874	.113
SOMMERVILLE.IN	CONS	.0			
SOMMERVILLE.OUT	BETA	.011	.008	.4736	.4444
WALLTOWNSHIP.IN	WEIBULL	.3618	.538	.6903	.282
WALLTOWNSHIP.OUT	UNIFORM	.107	.056	.03	.2
WHIPPANY.IN	WEIBULL	.053	.165	.4042	.0165
WHIPPANY.OUT	CONS	.0			
WILLOWGROVE.IN	NORMAL	.736	.361		
WILLOWGROVE.OUT	GAMMA	.955	1.25	.5562	1.717

NORFOLK ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
AHOSKIE.IN	CONSTANT	0			
AHOSKIE.OUT	CONSTANT	0			
ASHEVILLE.IN	WEIBULL	.128	.104	1.234	.1366
ASHEVILLE.OUT	WEIBULL	.966	1.322	.7418	.8035
BRISTOL.IN	EXPON	.0056	.0056		
BRISTOL.OUT	CONSTANT	0			
BYRD.IN	WEIBULL	.176	.174	1.01	.1768
BYRD.OUT	WEIBULL	.041	.075	.584	.0265
CHARLOTTE.IN	WEIBULL	.078	.038	2.188	.0878
CHARLOTTE.OUT	CONSTANT	0			
CHERRY PT.IN	GAMMA	1.83	1.33	1.898	.963
CHERRY PT.OUT	WEIBULL	.2024	.233	.8708	.1888
CINC.IN	GAMMA	.300	.232	1.678	.1789
CINC.OUT	GAMMA	.268	.167	2.554	.1047
CINCCOMP.IN	WEIBULL	1.073	.403	2.891	1.204
CINCCOMP.OUT	GAMMA	.138	.127	1.189	.1161
CMIO.IN	BETA	35.22	10.31	.5366	.604
CMIO.OUT	WEIBULL	29.05	9.476	3.384	32.35
FT MONROE.IN	GAMMA	.196	.129	2.289	.0855
FT MONROE.OUT	WEIBULL	.138	.403	.419	.0471
FT STOREY.IN	GAMMA	.023	.023	1.018	.0228
FT STOREY.OUT	WEIBULL	.010	.005	1.943	.0108
GREENSBORO.IN	GAMMA	.503	.074	.5297	.101
GREENSBORO.OUT	CONSTANT	0			
HICKORY.IN	CONSTANT	0			
HICKORY.OUT	CONSTANT	0			
JAX MCAS.IN	GAMMA	.3914	.514	.5803	0.6745
JAX MCAS.OUT	CONSTANT	0			
KNOWXVILLE.OUT	CONSTANT	0			
KNOXVILLE.IN	GAMMA	.263	.094	7.895	.0333
LANG480.IN	GAMMA	.712	.522	1.856	.3835
LANG480.OUT	GAMMA				
LANGLEY.IN	GAMMA	1.42	.988	2.065	.6879
LANGLEY.OUT	GAMMA	.475	.434	1.198	.396
LANTCOM.IN	WEIBULL	.1919	.159	1.213	.2046
LANTCOM.OUT	WEIBULL	.0754	.045	1.718	.0846
LEJEUNE.IN	WEIBULL	6.501	4.227	1.572	7.239
LEJEUNE.OUT	BETA	.600	.562	.2995	.4711
LITTLE CREEK.IN	GAMMA	.04	.033	1.461	.0274
LITTLE CREEK.OUT	CONSTANT	0			
LYNCHBURG.IN	WEIBULL	.014	.032	.4789	.0062
LYNCHBURG.OUT	CONSTANT	0			
NACSEC.IN	WEIBULL	.04	.001	48.13	.0408
NAVSEC.OUT	CONSTANT	0			
OCEANA.IN	CONSTANT	0			
OCEANA.OUT	CONSTANT	0			
OTC.IN	GAMMA	11.47	5.53	4.301	2.666
OTC.OUT	WEIBULL	8.093	2.285	3.971	8.932

Account	Curve	Mean	S.D.	Alpha	Beta
RADFORD.IN	WEIBULL	.014	.01	1.458	.0159
RADFORD.OUT	CONSTANT	0			
RALIEGH.IN	GAMMA	.023	.029	.5991	.0378
RALIEGH.OUT	CONSTANT	0			
ROSEY.IN	GAMMA	1.05	.664	2.515	.4188
ROSEY.OUT	WEIBULL	.983	.936	1.05	1.002
SACLANT.IN	WEIBULL	.705	.410	1.774	.7917
SACLANT.OUT	GAMMA	.996	1.27	.6146	1.62
SSOFIC.IN	WEIBULL	.428	.519	.8286	.3866
SSOFIC.OUT	GAMMA	.109	.048	5.148	.0211
SUBLANT.IN	EXPON	.0692	.0692		
SUBLANT.OUT	BETA	.132	.072	.3825	.4771
SUBLSSO.IN	WEIBULL	.24	.234	1.025	.2422
SUBLSSO.OUT	WEIBULL	.335	.173	2.031	.3776
SURFLANT.IN	WEIBULL	.016	.012	1.406	.0178
SURFLANT.OUT	WEIBULL	.07	.082	.8621	.0649
WILMINGTON.IN	UNIFORM	.025	.012	.005	.050
WILMINGTON.OUT	CONSTANT	0			

OFFUTT ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
CEDAR RAPIDS.IN	WEIBULL	.032	.04	.7947	.0277
CEDAR RAPIDS.OUT	25% = UNFRM(0,.1)				
CEDAR RAPIDS.OUT	CONS	0			
DES MOINES.IN	BETA	.062	.051	.2065	.4405
DES MOINES.OUT	UNIFORM	.001	.001	.0	.003
FORBES.IN	GAMMA	.120	.056	4.655	.0258
FORBES.OUT	34% = UNFRM(0,.1)				
FORBES.OUT	CONS	0			
FT LEAVEN.IN	GAMMA	.150	.070	4.573	.0327
FT LEAVEN.OUT	8% = .32				
FT LEAVEN.OUT	UNIFORM	.01	.03	.0	.02
FT LEONARD.IN	WEIBULL	.083	.127	.678	.0638
FT LEONARD.OUT	UNIFORM	.005	.002	.0	.01
FT RILEY.IN	WEIBULL	1.164	.980	1.192	1.235
FT RILEY.OUT	8% = 2.2				
FT RILEY.OUT	WEIBULL	.072	.059	1.238	.0772
KC.IN	WEIBULL	4.516	4.526	.9978	4.512
KC.OUT	GAMMA	2.83	2.91	.9444	2.997
MINNEAPOLIS.IN	GAMMA	.416	.167	6.212	.0669
MINNEAPOLIS.OUT	GAMMA	.171	.172	.9907	.173
MOLINE.IN	WEIBULL	.110	.152	.7321	.0902
MOLINE.OUT	UNIFORM	.12	.05	.0	.4
OFFUTT.IN	GAMMA	7.73	2.108	13.44	.575
OFFUTT.OUT	GAMMA	4.436	2.018	4.833	.9179
RICH GEBAUER.IN	WEIBULL	.603	.395	1.563	.6714
RICH GEBAUER.OUT	WEIBULL	.421	.220	2.002	.4755
SIOUX CITY.IN	GAMMA	.030	.018	2.935	.0103
SIOUX CITY.OUT	CONS	0			
SIOUX FALLS.IN	WEIBULL	.041	.038	1.083	.042
SIOUX FALLS.OUT	8% = .135				
SIOUX FALLS.OUT	UNIFORM	.001	.001	.0	.002
ST. LOUIS.IN	BETA	3.686	1.476	.4371	.4297
ST. LOUIS.OUT	BETA	3.72	2.241	.541	.8157
WASH.IN	GAMMA	9.302	2.491	13.95	.667
WASH.OUT	BETA	17.86	5.25	.463	.6583
WHITEMAN.IN	BETA	.816	.729	.3402	.6184
WHITEMAN.OUT	WEIBULL	.045	.081	.5846	.0286
WITCHITA.IN	BETA	.614	.409	.4372	.4863
WITCHITA.OUT	GAMMA	.040	.054	.555	.0726

SAN DIEGO ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
CMIO.IN	WEIBULL	36.52	8.339	5.017	39.77
CMIO.OUT	WEIBULL	33.13	3.47	11.52	34.62
CPPEND.IN	GAMMA	3.378	2.139	2.493	1.355
CPPEND.OUT	GAMMA	.058	.06	.9479	.0611
DAVISMONTHAN.IN	WIEBULL	.630	.269	2.499	.7095
DAVISMONTHAN.OUT	WIEBULL	.195	.193	1.011	.1956
ELCENTRO.IN	WEIBULL	.005	.006	.897	.005
ELCENTRO.OUT	CONSTANT	0			
FT. HUACHUCA.IN	GAMMA	1.736	1.091	2.532	.6857
FT. HUACHUCA.OUT	GAMMA	1.631	1.233	1.75	.9319
LOS ANGELES.IN	GAMMA	16.48	5.582	8.712	1.891
LOS ANGELES.OUT	GAMMA	6.506	2.606	6.23	1.044
LUKE.IN	GAMMA	.471	.448	1.102	.4269
LUKE.OUT	WEIBULL	.643	1.097	.615	.4413
MCAS YUMA.IN	WIEBULL	.613	.772	.8009	.5415
MCAS YUMA.OUT	GAMMA	.136	.232	.3464	.3938
SCOTSDALE.IN	BETA	.496	.408	.3273	.5893
SCOTSDALE.OUT	GAMMA	2.51	1.531	2.689	.9335
SDOTC.IN	CONSTANT	0			
SDOTC.OUT	WIEBULL	1.877	.816	2.455	2.116
TRAVIS.IN	WEIBULL	41.52	7.533	6.444	44.58
TRAVIS.OUT	GAMMA	52.42	20.72	6.402	8.188
WASH.IN	GAMMA	27.46	14.78	3.45	7.958
WASH.OUT	GAMMA	4.528	5.95	.5793	7.817

TRAVIS ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
ALAMEDA.IN	GAMMA	1.74	1.29	1.815	.9603
ALAMEDA.OUT	WEIBL	.779	1.55	.5446	.4507
AMEDEE.IN	WEIBULL	.012	.008	.7499	.0055
AMEDEE.OUT	UNIFORM	.020	.010	.00	.050
ARCATA.IN	TRIAG	.011	.003	(.003,.0143,.02)	
ARCATA.OUT	CONS	0			
BEALE.IN	TRIAG	1.01	.279	(.2,.1.286,1.6)	
BEALE.OUT	UNIFORM	.794	.446	.022	1.566
FALLON.IN	WEIBULL	.011	.013	.803	.0093
FALLON.OUT	CONS	0			
FRESNO.IN	WEIBL	.046	.046	.9867	.0452
FRESNO.OUT	UNIFORM	.005	.003	.0	.01
HAWTHORNE.IN	CONS	.012			
HAWTHORNE.OUT	CONS	0			
LEMOORE.IN	GAMMA	.193	.242	.6328	.3044
LEMOORE.OUT	20% = .12				
LEMOORE.OUT	CONS	0			
LIVERMOORE.IN	GAMMA	.332	.200	2.742	.1209
LIVERMOORE.OUT	GAMMA	.097	.109	.7983	.1215
MARE.IN	TRIAG	1.184	.604	(.05,.642,2.9)	
MARE.OUT	TRIAG	1.617	.935	(.05,.554,4.3)	
MATHER.IN	GAMMA	1.11	.995	1.248	.8904
MATHER.OUT	UNIFORM	.071	.034	.01	.13
MCCHORD.IN	UNIFORM	15.0	5.0	5.0	25.0
MCCHORD.OUT	UNIFORM	12.5	3.5	5.0	20.0
MERCED.IN	UNIFORM	.681	.213	.312	1.05
MERCED.OUT	UNIFORM	.038	.02	.0	.075
MOFFETT.IN	TRIAG	5.89	1.27	(3.99,4.17,9.5)	
MOFFETT.OUT	GAMMA	6.75	2.66	6.423	1.051
MONTEREY.IN	TRIAG	.313	.137	(.063,.1815,.7)	
MONTEREY.OUT	GAMMA	.075	.109	.472	.1581
OTC.IN	TRIAG	3.0	1.0	(.025,.26,9.5)	
OTC.OUT	UNIFORM	2.66	1.47	.101	5.3
RENO.IN	TRIAG	.0464	.0122	(.029,.0291,0.85)	
RENO.OUT	UNIFORM	.001	.001	.00	.002
ST ROSA.IN	UNIFORM	.008	.003	.0	.015
ST ROSA.OUT	CONS	0			
STOCKTON.IN	GAMMA	.16	.15	1.194	.1338
STOCKTON.OUT	UNIFORM	.01	.005	.0	.25
WASHINGTON.IN	TRIAG			(50,67,100)	
WASHINGTON.OUT	TRIAG			(50,85,120)	

WRIGHT-PATTERSON ACCOUNT SUMMARY

Account	Curve	Mean	S.D.	Alpha	Beta
BLOOMINGTON.IN	BETA	.253	.227	.2215	.4914
BLOOMINGTON.OUT	BETA	.082	.072	.3084	.5074
CHANUTE.OUT	UNIFORM	.003	.001	.000	.005
CHANUTE.IN	WEIBULL	.078	.07	1.114	.0811
CINCINNATI.IN	WEIBULL	.329	.467	.7191	.2664
CINCINNATI.OUT	GAMMA	1.54	.671	5.272	.2921
CLEVELAND.IN	WEIBULL	.296	.286	1.036	.3002
CLEVELAND.OUT	WEIBULL	.025	.030	.8555	.0234
DULUTH.IN	WEIBULL	.075	0.104	0.7358	.0623
DULUTH.OUT	UNIFORM	.008	.004	.000	.015
FINDLEY.IN	UNIFORM	.007	.003	.000	.015
FINDLEY.OUT	GAMMAA	.881	.231	14.57	.0604
FT BEN HAR.IN	WEIBULL	.323	.447	.7349	.2665
FT BEN HAR.OUT	WEIBULL	.167	.299	.5924	.1095
FT CAMPBELL.IN	WEIBULL	1.166	1.406	.8332	1.058
FT CAMPBELL.OUT	WEIBULL	.111	.141	.7917	.0969
FT KNOX.IN	WEIBULL	.135	.157	.8606	.125
FT KNOX.OUT	UNIFORM	.025	.015	.000	.050
FT WAYNE.IN	WEIBULL	.099	.076	1.317	0.1071
FT WAYNE.OUT	GAMMA	.063	.088	.5186	.1217
GLENVIEW.IN	GAMMA	.561	.0357	2.473	.2267
GLENVIEW.OUT	WEIBULL	.097	.094	1.025	.0977
GRAND FORKS.IN	UNIFORM	1.601	.737	.324	2.878
GRAND FORKS.OUT	WEIBULL	.035	.046	.7748	.0305
GRIFFIS.IN	UNIFORM	.558	.301	.036	1.079
GRIFFIS.OUT	WEIBULL	.102	.125	.8261	.0924
GRISSOM.IN	UNIFORM	.646	.285	1.52	1.14
GRISSOM.OUT	WEIBULL	.065	.101	.6619	.1071
K.I.SAWYER.IN	GAMMA	.511	.200	6.505	.0786
K.I.SAWYER.OUT	8% = .3				
K.I.SAWYER.OUT	UNIFORM	.007	.003	.000	.015
KELLY.IN	BETA	8.349	7.183	.2612	.4286
KELLY.OUT	GAMMA	13.76	9.097	2.287	6.015
LOCAL.IN	GAMMA	4.561	2.012	5.14	.8874
LOCAL.OUT	WEIBULL	2.54	1.83	1.402	2.783
LORING.IN	UNIFORM	.654	.29	.151	1.157
LORING.OUT	16% = .36				
LORING.OUT	UNIFORM	.004	.002	.000	.008
LOUISVILLE.IN	BETA	.300	.113	.5141	.6632
LOUISVILLE.OUT	GAMMA	.159	.103	2.365	.0671
MANSFIELD.IN	BETA	.029	.0154	.6062	.6106
MANSFIELD.OUT	UNIFORM	.010	.003	.000	.020
MILWAUKEE.IN	BETA	.219	.143	.6054	1.028
MILWAUKEE.OUT	16% = .12				
MILWAUKEE.OUT	8% = 1.8				
MILWAUKEE.OUT	UNIFORM	.014	.005	.000	.030
PADUCAH.IN	CONSTANT	0			

Account	Curve	Mean	S.D.	Alpha	Beta
PADUCAH.OUT	CONSTANT	0			
PEASE.IN	UNIFORM	.567	.273	.093	1.039
PEASE.OUT	17% = .175				
PEASE.OUT	8% = 6.3				
PEASE.OUT	UNIFORM	.007	.003	.000	.015
PLATTSBURG.IN	UNIFORM	.623	.285	.129	1.117
PLATTSBURG.OUT	GAMMA	.077	.086	.8002	.0961
RICKENBACKER.IN	BETA	.246	0.171	.3686	.6004
RICKENBACKER.OUT	BETA	.075	.076	.2219	.3775
SELFRIDGE.IN	WEIBULL	.547	.513	1.068	.5614
SELFRIDGE.OUT	WEIBULL	.245	.300	.3222	.3308
TERRE HAUTE.IN	UNIFORM	.02	.01	.000	.040
TERRE HAUTE.OUT	UNIFORM	.002	.001	.000	.005
TOLEDO.IN	8% = .13				
TOLEDO.IN	UNIFORM	.015	.005	.000	.030
TOLEDO.OUT	8% = .12				
TOLEDO.OUT	UNIFORM	.002	.002	.000	.005
WASHINGTON.IN	GAMMA	12.28	12.83	.916	13.4
WASHINGTON.OUT	WEIBULL	23.23	21.24	1.092	24.02
WURTSMITH.IN	BETA	.379	0.197	.4675	.4136
WURTSMITH.OUT	WEIBULL	.046	.075	.638	.0328

Appendix B: CONFIDENCE INTERVAL DETERMINATION

Given: $n = \dfrac{(\sigma Z_{\alpha/2})^2}{d^2}$

Where: $Z_{\alpha/2}$ = two-tailed standardized normal

n = sample size

d = desired error

Let $d = \sigma/x$

$n = 26$

$Z = 1.96$

Therefore $26 = \dfrac{1.96^2 \sigma^2}{\sigma^2/x^2}$

and $x = 2.6$

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This research develops an analytical model to assist the management of the Armed Forces Courier Services (ARFCOS) in making strategic planning decisions concerning its complex transportation network. ARFCOS delivers highly sensitive classified information to approximately 6500 customers served by 36 stations around the world. The research is limited to modeling 14 CONUS ARFCOS stations (ARFCOSTAS). The model is used to evaluate the current transportation network structure, determining the required weight bearing capacity of the vehicle to meet the maximum loading anywhere along a route. The model also provides data on manpower usage in terms of average number of people working and minimum and maximum number of people needed at one time. It provides the managers of ARFCOS a tool for analyzing alternative systems and the means of comparing different decision rules on the workings of the systems.

Simulation Language for Alternative Modeling (SLAM II) is the implementing language of the model. The theoretical distribution of the amounts of material picked up and delivered to 361 demand points are determined and used to compute maximum expected weights along [illegible] routes. The model is validated as an accurate representation of the current ARFCOS system. Conclusions and recommendations for consolidating stations, reallocating customers, and changing modes of transportation are discussed. The effects on manpower requirements of implementing selected alternative route or station locations are analyzed using the provided model.

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